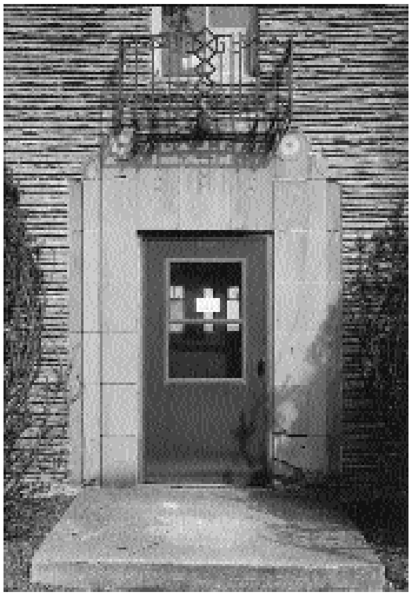

The door surround on the Wieboldt-Rostone House (Walter Scholer, 1933) is the only area of the exterior where the original building material,Rostone, a precast form of simulated masonry, is intact.

impression in the mortar. Several rollers of different sizes or textures could be used on the same project to achieve the desired effect. After the waxed paper is removed, the crinkled surface is scored with guide lines for the "mortar joints." Grooves are cut into the top layer with a chasing tool, which has two parallel cutting edges allowing for the creation of a mortar joint mimicking those found in natural stone construction. The groove may be left unfinished or may be pointed with mortar.

A variety of finishes can be created with different textures (using different rollers) and colors. Most tinting is created by adding color into the mortar mix, but surface color could also be achieved by dashing colored powdered materials such as "mica, oxide pigments, stone dust, slate dust or chips of mineral or artificial stone ... on the outer layer. This produces a speckled surface, simulating particular natural rocks or stones." The powdered material is placed on the surface either before the waxed paper is applied or after the texture of the stone has been created and the wax paper removed.

Formstone seems to have been marketed as a product to refurbish and modernize existing buildings of any type. It was promoted as a material that could solve problems of deteriorating masonry and stone structures and poor insulation. Purchasers received a 20-year guarantee and assurances that the wall facing was "maintenance free." Baltimore, with its large number of brick buildings of an indigenous soft brick, became the "Formstone capital of the world."

Simulated masonry products reached their zenith during the 1950s, but by the early 1980s interest in such products had nearly ceased. Other products such as vinyl and aluminum siding were mass-produced and more economically installed on both new and existing construction. More importantly, these new products appealed to the changing public aesthetics. However, both Perma-Stone and Formstone are still being produced in small quantities today. The countless examples of simulated masonry across America are reminders of the public's penchant for remodeling houses.

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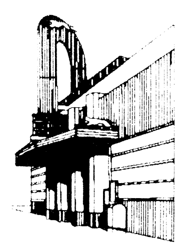
Bruce S. Kaskel

The Metal and Glass Curtain Wall



The era following the World War II saw the development of new technologies that had a fundamental effect on the curtain wall. Principal to these new technologies were improvements in aluminum, glass, sealants, and insulation materials.

Aluminum was first isolated in 1825 but was not produced on a large scale until after 1889, when Charles Martin Hall was granted a patent for a process by which aluminum could be made on a commercial scale. By the 1920s, aluminum was being incorporated into building details such as doors, windows, trim, and exterior signage. Although aluminum costs three to four times as much as a comparable steel section, architects still found frequent cases where the expenditure was justified.

The onset of World War II saw aluminum production soar, since it was the principal material of many war materials. During the war, more than 200 factories produced a multitude of aluminum shapes. After the war, the abundant production capacity created a demand for new aluminum applications and at the same time the price plummeted.

Aluminum found a welcome niche in cladding curtain walls. The material was more corrosion resistant and lighter than steel and certainly much lighter than masonry. Aluminum curtain walls were relatively easy to erect, especially in cold weather which significantly limited the ability to erect walls of brick and mortar. Aluminum curtain walls were also thinner, freeing up valuable floor space for lease. This had the advantage of increasing the rentable floor area. This advantage was estimated to add $18 per linear wall footage in savings in the 1950s.

The principal forms of aluminum were twofold: rolled aluminum sheet, which was flattened and stamped to create opaque wall panels; and extruded aluminum shapes, made by forcing the molten aluminum through a steel die. Extruded aluminum resulted in long lengths of aluminum of almost any cross sectional shape, only limited by the possibilities in die fabrication. Aluminum extrusions were highly consistent in dimensional qualities and were therefore usually employed as the principal framing members of curtain walls. Figure 1 shows the installation of fabricated sections at Mies van der Rohe's 860-880 Lake Shore Drive apartment buildings in Chicago.

While extruded aluminum was used as the framing members of curtain walls, glass was the principal material for the in-fill between those aluminum extrusions. The post-war commercial adaptation of air conditioning compensated for the heat gain and thermal inefficiencies of larger areas of clear glass. Large unimpeded views through clear glass had always been a desirable feature for the office environment. Now larger glass panels could be set within minimally thin aluminum "sticks."

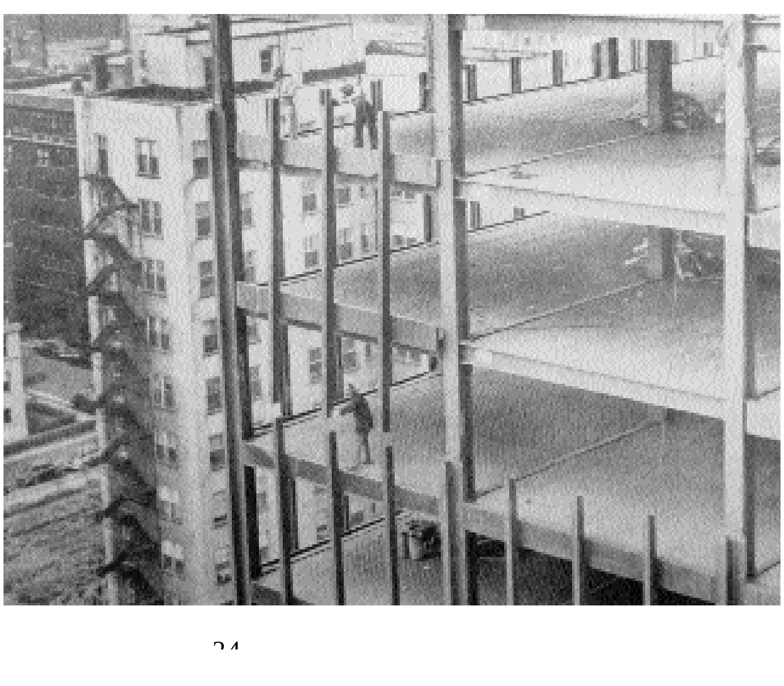


Fig.1.Construction photograph of 860-880 Lake Shore Drive apartment buildings, Chicago, Illinois (Mies van der Rohe, 1949-1951).These were among the first residential buildings in the United States to be clad entirely in glass, with a two-story prefabricated steel and aluminum curtain wall system.

Glass technology also made numerous advances in the post-war years. Prior to the 1950s, glass for buildings was made by either the sheet or plate process. These processes had limitations on the size of the glass and were not able to produce absolutely flat and uniformly thick glass. This lead to inevitable distortion of vision through the glass process.

In 1959, Pilkington Brothers Limited produced the first glass by the float method. This process which floats a ribbon of glass on molten tin while heating both sides of the glass, produces perfectly flat and parallel surfaces. This technology took off and within a decade, float glass was produced in many different countries and was replacing the plate glass process. Most float glass was finish by controlled cooling through a process called "annealing." As high performance coatings and uses for curtain wall glass came in demand, stronger glass manufactured by tempering or heat strengthening, instead of annealing, became popular.

Large glass panels had the disadvantage of transmitting heat and glare from the sun. Metallic oxides were added to the manufacturing of the glass to absorb heat and light and to aid in creating more comfortable conditions for building occupants. Still, large glass sheets will transmit significant heat gain in the summer and heat loss in the winter.

It wasn't until the energy crisis of the mid-1970s, that architects began to demand more efficiency from aluminum and glass curtain walls. Insulating glass (IG) units, created by factory sealing together two sheets of glass with a thin air space between them, vastly improved the energy performance of glass lites. Early IG units were sealed with a metal edge band. These have proven to be problematic, since water can become trapped between the glass and the metal edge band, ultimately leading to failure of the IG unit. Improvements in aluminum framing with plastic thermal break materials reduced conduction of heat through the curtain wall. More recently research into improving the thermal performance of glass has led to development of low-emissivity metallic coatings, gas filled units and photo-responsive units.

The demands of the aluminum and glass curtain wall also lead to improvements in joint sealants and thermal insulation materials. Early metal curtain walls were caulked with glazing compounds that quoting one practitioner, "were little more than vegetable oil stuff." Such caulking materials, proved to have little ability to stop water, and required frequent reapplication. Improved sealants were developed which adhered better to metal and glass and consequently were more watertight. Two-part elastomeric sealants principally made from polysulfide were developed in the late 1950s. These sealants were generically identified by the principal manufacturer, "Thiokol." The components were mixed with a paddle and had a limited four-to-six hour pot life. Later, Tremco developed a one-part sealant called "Mono" which, although the smell was less than appealing, exhibited tenacious adhesion. Mono sealants, however, hardened over time. This has contributed to glazing failures due to the hard sealant compressing on the glass. Contemporary one-part elastomeric sealants such as silicones and polyurethanes were first marketed in the 1970s, and remain the common sealant materials today.

Insulation materials such as fiber-glass and mineral wool blankets were developed by manufacturers such as Pittsburgh-Corning, Owens-Illinois, US Gypsum, and Johns-Manville. These materials were touted for their significant contribution in reducing heat loss. One source noted that, "many of the insulating materials suitable for thin curtain wall construction are more than 15 times as effective as thermal insulators than ordinary masonry."[1]

Although the new materials had infinite promise in creating new claddings, many 1950s vintage curtain walls were only half-hearted efforts at incorporating the technology. Curtain walls often were little more than an assembly of old style aluminum windows held in place with a grid of reinforced mullions. Many early "all-glass" curtain walls were actually backed by concrete block walls at each floor behind opaque glass, to satisfy prevailing fire code requirements. Lever House in New York, shown in Figure 2, is an example of early curtain wall construction in the United States. The all glass building also suffered from a lack of consideration about orientation. Long walls of glass were faced on the south, east or west, which exposed occupants to the intense morning and afternoon sunlight and glare. Glass exposed to direct sunlight has been found to cause thermal stresses that can crack the glass, especially in situations where the glass is partially shaded by awnings or deep exterior mullions.

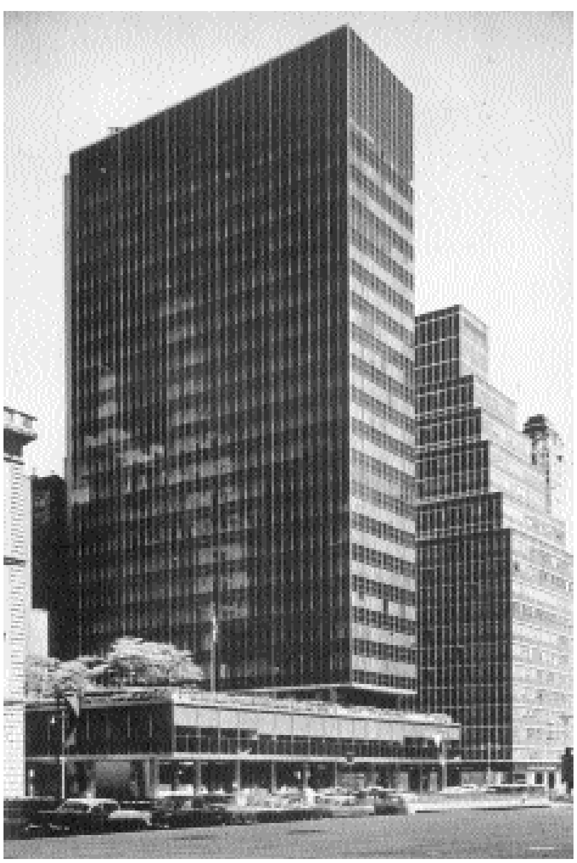


Fig.2. Lever House, New York, New York (Skidmore, Owings and Merrill, 1952). The clean curtain wall appearance "belies its complex internal construction which was cobbled together from off the shelf parts," as described in Architectural Record, *June 1989.*

The new curtain wall also created new problems, of which architects and builders were not completely aware. Interior condensation and rapid expansion/contraction became new design concerns. Although aluminum is corrosion resistant, mill finished aluminum can corrode over time and with exposure to atmospheric pollutants and moisture. Early curtain walls were also prone to leak. Furthermore, when water did get past the curtain wall, it was nearly impossible to track its path and find the leak. Therefore, early designers realized that they needed to find a way to let water that got into the wall back out again, before it became a leak on the interior. A double system of drainage with weeped internal gutters was commonly utilized to collect and hold water at the spandrel area. These gutters could be designed to hold up to a 6" head of water, and to allow the water to drain out when wind pressure subsided. Problems with water leaks are still evident with many curtain walls due to the misunderstanding of how to design for water infiltration or due to poor quality workmanship in implementing a water resistant design.

Standards and the Metal and Glass Curtain Wall

As with any material in its infancy, it soon became apparent that standards of quality and performance were needed. An early curtain wall symposium defined the ideal technical parameters of a metal and glass curtain wall as being between 2" and 5" thick; self-insulating; able to withstand high winds; weatherproof on the outer surface; vapor-proof on the inner surface; ventilated and drained for control of internal moisture; designed for expansion and contraction of the building; easily removable for repair; sound deadening; adaptable to all types of building frames; installed from the inside without scaffolding; easy to fabricate, ship, and handle; attractive; maintenance free; and moderate in cost. Furthermore, this system was intended to last 40 to 100 years.

As the metal and glass curtain wall industry developed, and lessons were learned about the performance of these walls, it became apparent that performance testing of mock-ups of the curtain walls could go a long way to alleviating expensive problems in the field. Some of the earliest mock-up tests of a metal curtain wall were performed in the early 1950s in a laboratory in

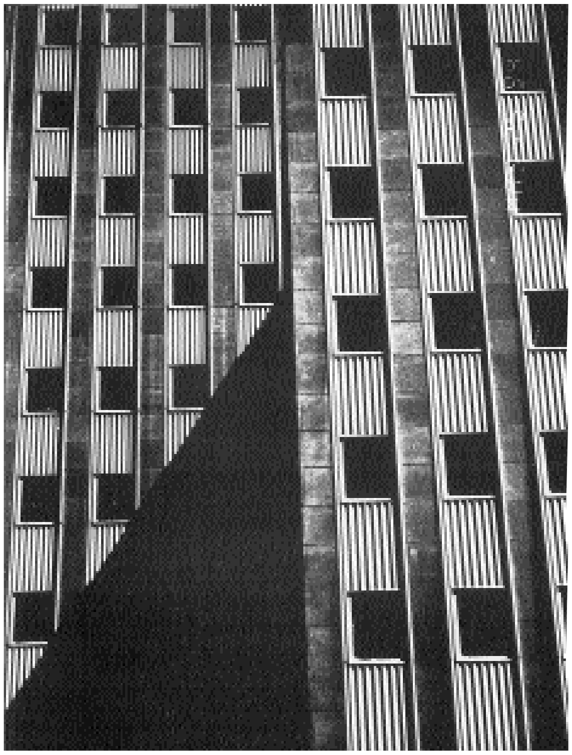


Fig.3.An early aluminum curtain wall used in conjunction with the then more traditional limestone curtain wall. The fluted aluminum spandrel plates and center pivot windows have contributed to water leakage over the years.

Coral Gable, Florida. The tests were performed on curtain wall mockups for Chicago's 900-960 Lake Shore Drive Buildings designed by Mies van der Rohe. Similar to the mock-up testing performed today, these tests subjected the mock-up to water and air pressure differentials, and used both static and dynamic test methods.

Guidelines for the performance of curtain walls were introduced through manufacturer's organizations such as the National Architectural Aluminum Manufacturers (NAAM) and later through the Architectural Aluminum Manufacturer's Association (AAMA). National consensus standard organizations, such as American Society for Testing and Materials (ASTM) have adopted many of these manufacturers' group standards. Through these organizations, structural performance, thermal performance, water resistance performance and air infiltration limits were established. More recently, requirements have been promoted for resistance to condensation and for high performance paint coatings.

As curtain walls became lighter and the buildings clad with these walls became taller, it soon became apparent that the most significant force acting on the curtain wall was not its own dead weight, but instead was the "live load" imposed on the wall by the force of the wind. Through the development of boundary layer wind tunnel testing, there arose a better understanding of the effect of wind loads on curtain walls. Wind tunnel testing revealed that not only was the wind force greater higher up on the building, but wind forces varied considerably depending on the topographical conditions around the building, the shape of the building, and the orientation of the building. Wind tunnel testing also clearly revealed the effects of vortex currents which create high wind suction at building corners.

Maintaining and Servicing the Metal and Glass Curtain Wall

Although the early advocates believed that curtain wall maintenance would require, "no painting, caulking or refinishing, cleaning not required for durability or appearance," this has not proven to be true. Curtain walls, like all claddings, require work to maintain them in a serviceable condition, and often require major repairs to restore them to their original condition. These repairs are often undertaken to refresh a dated facade and to aid in leasing an older building. With proper upkeep the 1950s and 1960s curtain walls can continue to last as long as their masonry counterparts.

Sealant replacement is the most common maintenance requirement for the middle-aged metal and glass curtain wall. Figures 3 and 4 show an early curtain wall and the maintenance for its continued performance. Early generations of polysulfide sealants become embrittled over time and will no longer stop water entry into the wall. "Mono" sealants can harden and contribute to glazing failures due to the sealant compressing the glass. Butyl sealants, which remain flexible over time, can be pushed out of the sealant joint by the repeating action of winds pushing against the aluminum and glass. Old sealants can usually be replaced by cutting out the old material and clean-

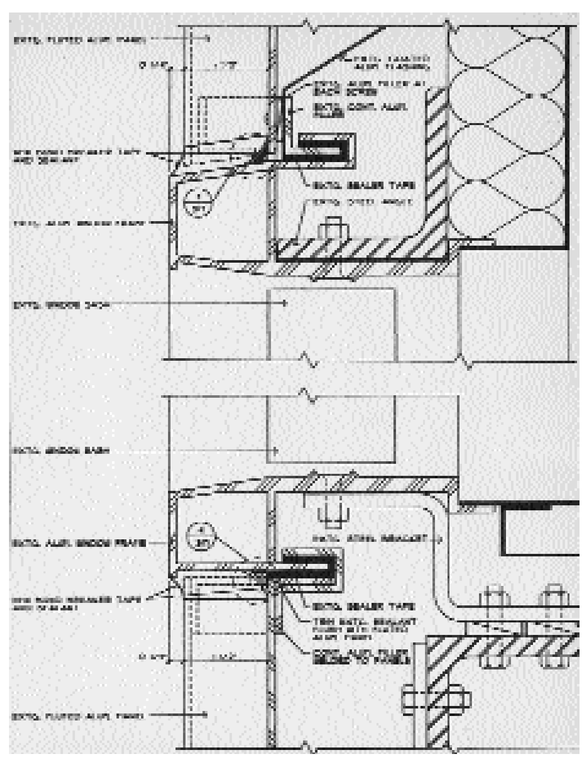


Fig.4.A section at the window head and sill conditions for the curtain wall shown above. Sealant repairs have been specified at key locations to mitigate water leakage.

ing the substrate with a suitable solvent and clean cloth wipe. Then after preparation, the new material can be installed in a properly designed new sealant joint.

Glass replacement is sometimes warranted, either due to physical damage to the original glass or due to the benefits inherent with replacing older and often times energy-inefficient single-glazed curtain walls with high performance insulating glass (IG) units. Even early generation 1970s IG units may now need replacement, due to the breakdown of the metal edge bands and fogging of the IG unit with water vapor. Large glass units that pushed the limits of annealed glass for thermal stresses can crack and need replacement. Tempered glass can spontaneously break due to mineral inclusions in the glass and may require preventive measures to safeguard against glass fall-out. Laminating safety films are sometimes applied to the interior face of tempered glass to correct this problem.

Although the aluminum components of the curtain wall are considered corrosion resistant, mill finished aluminum can corrode over time with exposure to atmospheric pollutants and moisture. The anodized coating on finished aluminum can discolor and pit. Sometimes, the original color just looks old and tired, and like many building materials, requires a fresh coat of paint. High performance air drying paints are available for the repainting of aluminum curtain walls. These high performance paints are banned in some areas of the country because of volatile organic compound (VOC) restrictions.

When maintenance and servicing are not deemed sufficient to correct the look or function of an older curtain wall, recladding of the entire building is possible. The new lightweight aluminum curtain wall can be installed directly over the old wall. Even with the weight of two exterior walls, the system is still usually lighter than a masonry wall system. Prior to implementing an overcladding project, however, it is critical to consider what will be buried in the wall, such as internally corroded metals, water damaged materials, and even molds and mildew.

The metal and glass curtain wall of the 1940s, 1950s, and 1960s was a product of its time: the continued desire for lightweight, high performance, and economical wall systems, coupled with industry advances from the war years. The industry has progressed with new standards of construction and methods for quality control testing to improve new construction. However, older metal and glass curtain walls can still serve for many years with careful maintenance and repair.

Notes

1 *Architectural Forum* (March 1950): 83.

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Thomas C. Jester

International Perspectives on 20th-Century Heritage

Americans are not alone in their efforts to preserve cultural resources from the 20th century; other countries have likewise begun to consider more recent aspects of the built environment for their heritage value. In response to known and potential threats, particularly rapid change in the environment, the notion of heritage is slowly expanding to include significant 20th-century properties. Because the public often views heritage as a way to distinguish the past from the present, it is difficult to argue that 20th-century properties are worth preserving. This is particularly true in countries with resources dating back many centuries, where 100 years is considered a short period of time. The vast number of properties from this century also makes selecting properties worthy of preservation more challenging, a problem exacerbated by the relative dearth of objective historical analysis on 20th-century buildings and sites. Changes to properties over time and accelerated deterioration due to limited lifespans of some buildings also raise questions about integrity. With so many issues to