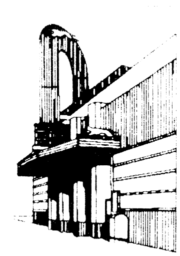
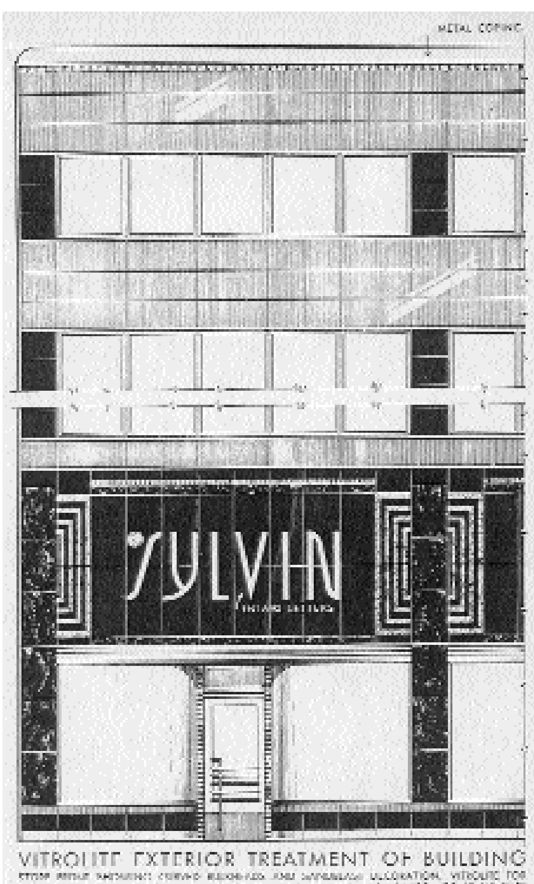
Carol J. Dyson and Floyd Mansberger

Structural Glass: Its History, Manufacture, Repair, and Replacement



Colored opaque structural glass was once widely used in this country. Although it is no longer manufactured in the United States, structural glass is still best known by the historic proprietary names of "Vitrolite" and "Carrara." This paper discusses the history, manufacture, and characteristics of structural glass and the repair and replacement options available today.

Colored opaque structural glass was fused at high temperatures, rolled into slab form, slowly annealed, and mechanically polished. Historically, the glass was marketed in black, white, and a variety of colors and finishes. The glass has also been known by many other terms, including recreated rock slab, sanitary glass, rolled or opaque opal glass, and heavy obscured structural glass. Besides Vitrolite and Carrara, other trade names included "Sani-Onyx," "Argentine," "Marbrunite," "Nuralite," and "Opalite."



Inlaid letters, curved bulkheads and sandblasted decoration combine in this advertisement rendering to demonstrate the versatility of Vitrolite. Source: Sweet's Catalogue, *1937,17/20.*

Composition and Production

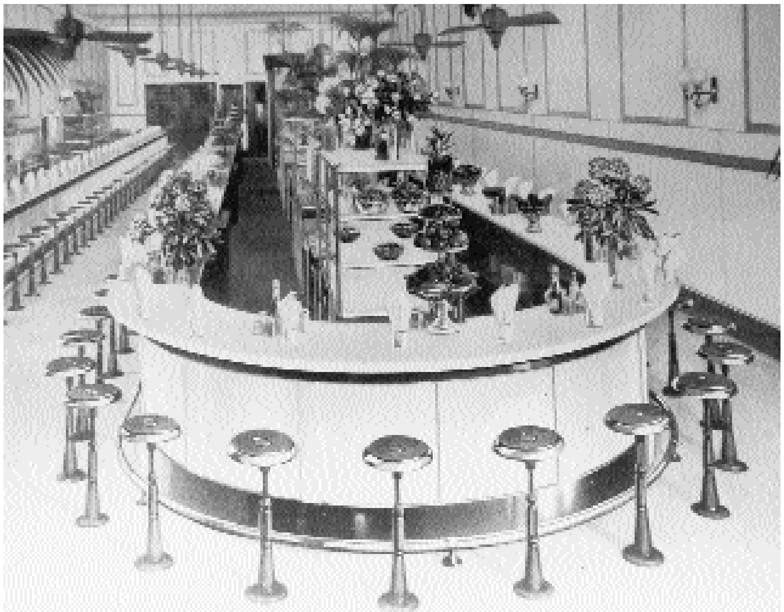
Opaque structural glass was composed of silica, feldspar, fluorspar, china clay, cryolite, manganese, and other materials vitrified with intense heat (about 3,000 degrees F). The opacity of structural glass was created by the addition of fluorides into the batch. Upon annealing, the fluorides precipitated, creating a dense mass of particles suspended in the clear matrix. The fluoride particles would scatter, reflect, and trap light until the glass was semi-translucent or completely opaque. Colors were added to the clear matrix before firing.

After the materials were vitrified in pots or tanks, the sheets were then rolled to the desired thickness much like plate glass. The glass was annealed (cooled) much more slowly than modern plate glass, taking from three to five days—depending on the thickness. The process demanded exact control of the temperature and speed of the annealing process in order to provide consistent opacity, color, and finish. The glass was sometimes "hardened" by use of rapid heating and cooling methods to increase its strength. At this point the glass finish was "fire polished." Some applications made use of this soft finish without further polishing. To achieve a more glossy finished glass, the surface of the slabs were mechanically ground with fine sand and rollers and then polished to a mirror-like finish with felt blocks and rouge. After polishing, the slabs were cut to size. Normally the material was cut, holes drilled, and the edges finished to the owner's specifications in the factory.

Early History and United States Production

The use of glass in imitation of other materials has a long history. Colored, semi-translucent glass was first developed in ancient Egypt and Rome in imitation of stone and marble. In the 16th century Venetian craftsmen were producing a semi-translucent glass by adding fluorides such as cryolite to the matrix. The Chinese also added cryolite to glass to produce an imitation porcelain.

In the United States, at the end of the 19th century, the development of the regenerative furnace and the discovery of natural gas reserves in Pennsylvania, West Virginia, Oklahoma, Arkansas, Texas, and Missouri led to a rapid expansion of U.S. domestic flat glass production. The resulting investment of capital laid the foundation for varied innovations in technology and production of flat glass during the early-20th century.



Structural glass was popular in restaurants due to its sanitary, non-absorbent and non-staining qualities. This restaurant had Carrara and Black Glass walls, wainscotting, counters, aprons and shelving. Source: Glass, Paints. Varnishes and Brushes: Their History, Manufacture, and Use, *1923.*

Opaque structural glass slabs were first developed about 1900 as a sanitary alternative to white marble slabs for wainscoting or table surfaces. The product, Sani-Onyx, was created by the Marietta Manufacturing Company. About the same time the Penn-American Plate Glass Company began production of Novus Sanitary Structural Glass. By 1906, the Pittsburgh Plate Glass Company (PPG) had begun production of Carrara glass in white and black.

Eventually, approximately 10 U.S. firms were producing structural glass, but the two products that dominated the market were Carrara and Libby-Owens-Ford's Vitrolite (which appeared on the market about 1916). By 1929, U.S. production of opaque structural glass was over five million square feet, and the glass was being marketed in a variety of colors and finishes.

Although some structural glass was imported (primarily from Belgium and Czechoslovakia), imports constituted less than 5% of the U.S. market. Although the U.S. discontinued production in the early 1960s, structural glass continues to be produced today in Czechoslovakia and Japan.

Early Uses of The Material

When it was first introduced around 1900, structural glass was marketed as comparable to statuary marble in appearance, but, due to its smooth impervious surface and non-absorbent qualities, easier to clean and more sanitary. The fact that the glass was homogenous, non-porous, non-crazing, and could be produced in large sheets made it more appropriate than marble or tile for aseptic conditions such as hospital fixtures and surfaces.

During the first two decades of the 20th century the material was primarily used in utilitarian locations requiring durable, non-staining, easily cleaned and maintained slab materials: wainscoting, flooring, refrigerator linings, lavatories, table and counter-tops, bank coupon desks, and electrical switchboards, and in places such as hospitals and bakeries. The ability of the material to reflect light without glare also made it suitable for corridors, operating rooms, and laboratories. In these years structural glass was also being used on exterior surfaces, especially storefronts, where it was substituted for stone in bulkheads and dados.

At the Peak of Popularity

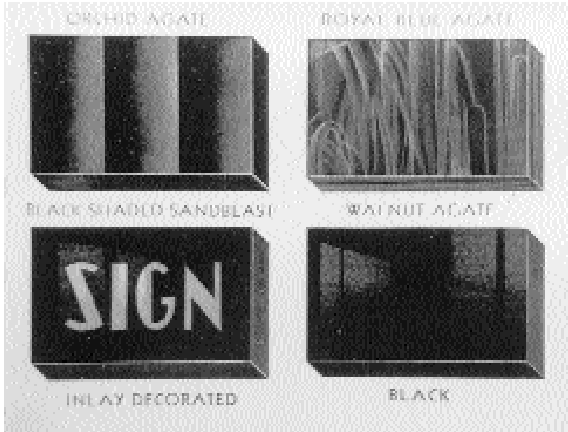
Although as early as 1906, the Penn-American Plate Glass Company was producing their Novus Sanitary Structural Glass in various colors, up until about 1930 most structural glass was produced only in shades of white, off-white, and black.

The softer "fire polished" and "satin" (the more marble-like) finishes also predominated the early applications. By the 1930s, however, the glossy, colorful, mirror-like finishes became popular, being well-suited to the Art Moderne aesthetic.

With the development of the new design aesthetics of Art Deco, Art Moderne, and Streamlined Modernism, structural glass reached its greatest popularity. The variety of colors and versatility of the glass led to its wide acceptance during the 1930s and 1940s. By the late 1930s, structural glass was available in over 30 different colors ranging from pastels to jewel tones, and solids to striated "agate" and "dendric" patterns. The material could be bent, carved, laminated, inlaid, and sandblasted, or painted with gold, silver, or color at the factory. The glass was installed in sleek "moderne" office building lobbies, movie theaters, restaurants, and confectioneries, among other places. The glass also proved to be an ideal material for "modernizing" the exteriors of older structures.

Early use of the material on building exteriors was in simple bulkheads and dadoes. The signage shown here was sandblasted and then painted. Source: Glass, Paints, Varnishes and Brushes: Their History, Manufacture, and Use, *1923.*

New construction for storefronts, movie theaters, gas stations, and auto



Structural glass could be bent, carved,sand-blasted,inlaid, painted and came in a variety of colors and finishes. Vitrolite's variety of decorative finishes are shown here. Source: Sweet's Catalogue, *1937, 17/20,1936.*

dealerships were clad in gleaming structural glass set in aluminum glazing systems. PPG produced their own complement to Carrara, Pittco-Carrara Glass Store Fronts, in which the metal window sash overlapped the Carrara facing material to protect the edges. In order to promote the use of Vitrolite in new construction, the Libby-Owens-Ford company offered a prefabricated Vitrolite-faced concrete masonry unit called Glastone. Opaque structural glass was no longer seen as a substitute for stone—it was extremely popular in its own right.

Late Use of the Material

By the 1950s, structural glass was losing its popularity. Changing design tastes, and competition from other materials such as plastic laminates and ceramic panels, were eroding its market. Although still utilized for storefronts, structural glass advertisements in the 1950s now emphasized the same purpose for which it was originally designed: use in utilitarian spaces such as residential and commercial bathrooms and kitchens.

A 1959 Carrara brochure is the last time structural glass was prominent in Sweet's Catalogue. In that edition, Carrara glass was being (unsuccessfully) marketed by PPG as a spandrel glass, and was available in the traditional "polished," "suede," and a new "rough" texture. Possibly the new coarse texture was designed to compete with other new materials such as textured porcelain enamel panels. A 1963 PPG brochure on curtain wall systems discussing Carrara as a spandrel panel choice is the final time the material is seen in Sweet's Catalogue. PPG kept the trade name listed in the Sweet's index until 1969, but the material was no longer displayed.

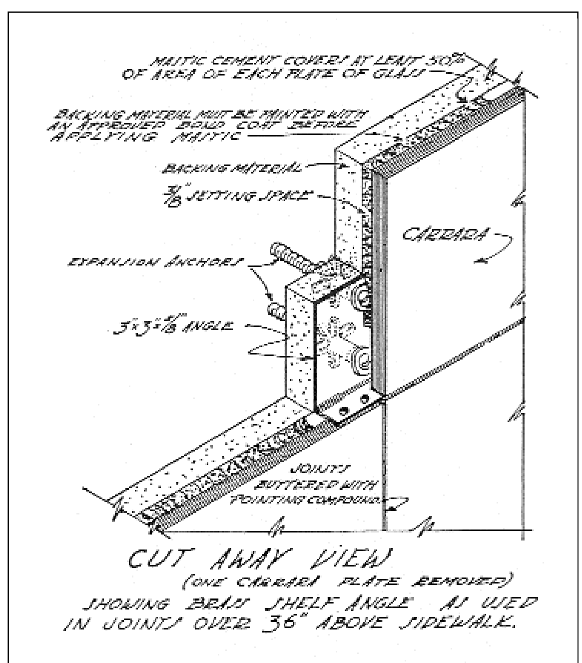
Material Installation

During its 60-plus years of domestic production, structural glass was available in thicknesses from 1 /4" to 1-1 /4". The panel sizes were determined by use. On exteriors the maximum size was six square feet if the panel was to be installed 15' or more above the sidewalk, and 10 square feet if installed below 15'. Interior wall panels could be sized up to 15 square feet. Toilet partition panels could be produced in sizes up to 25 square feet and were created by laminating two 7/8" slabs together with bituminous adhesives.

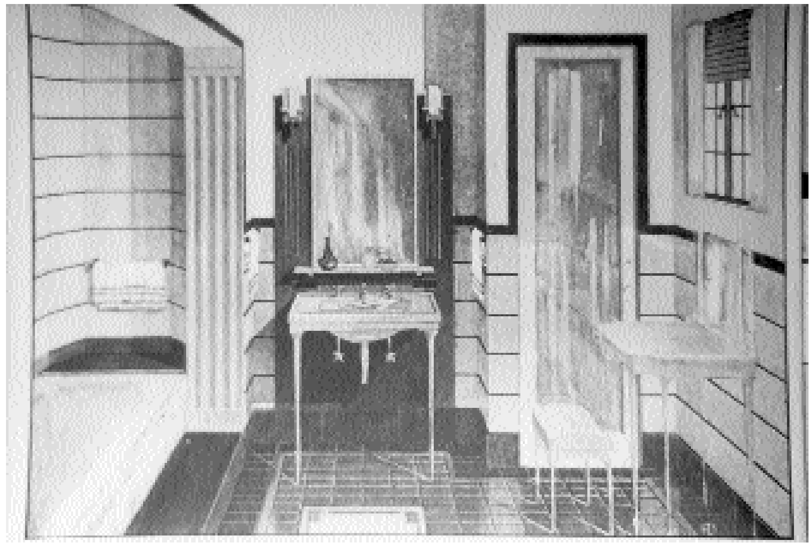
The versatility of the material was partly due to its tolerance of various substrates. The glass could be readily applied to most flat surfaces, including plaster on metal lath, concrete, or masonry. Wood substrates, however, were discouraged. The backing surface was prepared and sealed with a bonding coat supplied or approved by the glass manufacturer. The mechanical fasteners (non-ferrous metal brackets, angles or channels) were secured to the substrate. The panels were pre-fabricated at the factory to specifications and were attached with an asphaltic mastic. The mastic was applied to the back of the glass in 3" daubs covering 50% of the back of the panel. The glass was set in position by rocking the panel until the flattened mastic was forced into the back-up surface providing a keying action. When the cement was set, the joints were pointed with a pointing cement, which, like the mastic, was provided by the glass manufacturer. Panel edges could be protected with 1/16"-thick cork tape, which was set back 1/8" from the front of the glass. In locations where high moisture was expected (such as tub surrounds) and the backup substrate was masonry, the panels were sometimes attached with cement rather than mastic. On exteriors, non-ferrous angle irons or clips helped hold the panels in place.

Condition Assessment

Much of the popularity of opaque structural glass was due to its durability. The glass does not warp, craze, fade, or easily stain, and resists most



Installation details for a typical Carrara veneer storefront.Source: Glass and Storefront Products, *1940.*

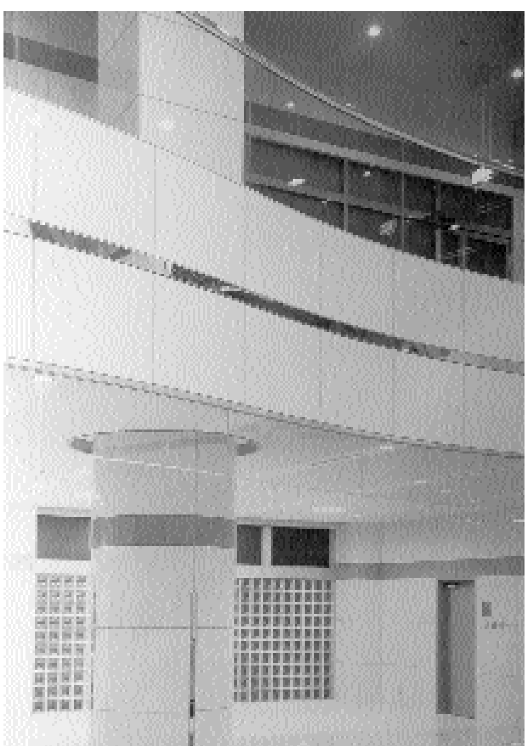


Polychromatic Vitrolite brightened residential bathrooms and kitchens. Source: Bathrooms and Kitchens of Distinction with Carrara:The Modern Structural Glass, *circa 1935.*

acids. When structural glass panels do fail, it is from either impact or deliberate alterations (such as installation of new fixtures) and is manifested in cracks, holes, and chips.

Because 1) the material is non-absorbent, 2) most fasteners for structural glass are non-ferrous, and 3) the plastic nature of the mastic is forgiving, there is less reason for severe deterioration from moisture than with clay-based masonry products. The mastics and pointing cements are the weak link in the system. Although the mastics are durable, they harden over time. The pointing cements also gradually deteriorate. The dark shades of structural glass absorb a significant amount of heat, causing the panels and walls to be subjected to more thermal stress. Although they were often heat-tempered, the joints on dark facades are exposed to more thermal expansion and contraction.

Most failures in structural glass systems are readily obvious: panels are visibly cracked, damaged, missing, out of alignment, or delaminating, joints are deteriorated, or water intrusion is evident. Because most exterior installations are below 15', the panels are easily accessed. One can gently push on a panel to see if it is still securely adhered to the substrate. If a wall has been subjected to severe water damage, then removal of selected panels may be necessary to determine the stability of the mastic and the substrate.



Several Japanese firms still produce colored structural glass, including NEG's NeoClad, shown here. Source: "Exclusively NeoClad, Architectural Panels," Nippon Electric Glass Co.,Ltd., Glass and Storefront Products, *1940.*

Conservation Techniques

Because structural glass is no longer produced in the U.S., repairing, whenever possible, rather than replacing, is the best approach. Maintenance of structural glass is straightforward. The glass can be cleaned with water and ammonia or detergent. Joint repair can be done with traditional joint cement (with an integrated watertight surface), latex caulking, or glazing compound. Silicone sealant is reportedly harder to control due to the fine joints. Traditionally, joint cement was colored to match the glass. New materials should also be tinted to match, with pigments compatible with the joint patching material.

Minor hairline cracks can be filled with caulking tinted to match the glass. One method for repairing chips or holes is to fill the defect with polyester resin adhesive tinted to match the glass. The surface can then be polished with fine sandpaper and buffed with polish. Tim Dunn of Vitrolite Specialist, a St. Louis contracting firm that specializes in the restoration of this historic glass, has had success filling the hole with glazing compound and then painting the area with computer color-matched paint.

Removal

Removal of structural glass panels is difficult due to the gradual hardening of the mastics and the fine joints between panels. Two publications on structural glass, Douglas Yorke's article in *The Association For Preservation Technology Bulletin*, Materials Conservation For The Twentieth Century: The Case For Structural Glass, and the National Park Service's Preservation Brief No. 12, *The Preservation of Structural Glass*, have excellent discussions of the repair and removal of structural glass panels.

No method is immune to glass breakage. Commercial solvents can be injected behind the glass to soften the mastic. Then piano wire can be slipped behind the panels to cut through the mastic. Another method, reportedly effective but time consuming, is to direct steam for approximately 10 minutes at the face of the panel to soften the mastic. The panels can then be pried or sawn off. When prying glass panels off, a block of wood should be used to protect the face of the glass from the crowbar or nail puller.

In-kind Replacement

Colored opaque structural glass is no longer manufactured in the United States. When pieces are broken, severely damaged, or missing, finding an appropriate replacement material is difficult.

However, when structural glass manufacture was discontinued, many glass shops were left with large inventories. Occasionally shops still have stock left in warehouses today. Salvage of used material is difficult but a few architectural salvage yards, or glass repair specialists, may be able to locate a supply. Karl Platt, a glassmaker and preservationist in Milton, Virginia, has a substantial stockpile of structural glass he has purchased from glass shops over the years.

One kiln in Czechoslovakia still produces structural glass in the traditional method. The material is distributed in the United States by Floral Glass and Mirror of Hauppauge, New York, but there are limited choices in size, colors, and finishes.[1] The panels are sized metrically and are approximately 1/4" thick. They are produced in black, white, mint green and beige. Differences in the panel thickness may be adjusted for with the mastic and mechanical fasteners. Metric panels could be cut down to fit the necessary English dimensions.

Japan has at least two new products that are similar to historic structural glass. NEG Industries' NeoClad is an opaque colored glass that comes in white, beige, and gray colors. ASAHI Corporation is producing an opalescent, nearly opaque structural glass in white and light gray. As with the Czechoslovakian glass, limited colors, metric sizes, and the cost of shipping to the United States, make matching the size, strength, finish, reflectivity, and color of domestic glass problematic.[2]

Substitute Materials

Another glass material that is often suggested as a substitute material is spandrel glass (backenameled clear glass). With the advent of computer color-matching, back-painted or backenameled glasses may be adequately matched in color. The clear depth of material, however, does not provide an appearance of homogenous opacity, and ultraviolet light may fade the colors. Experience has shown that the edges of the glass are visible, which emphasizes the lack of true opacity. Polishing and painting or enameling the edges to match the back could help solve this problem.

Mary Oehrlein of Oehrlein and Associates, Architects, in Washington, DC has researched various materials as substitutes for structural glass. One product she has suggested that holds promise is laminated glass. In a custom job, the translucent, colored polyvinyl inner layer(s) can be laminated a mere 1/8" from the outer face of the glass and might suggest the desired color opacity. The combination of colored translucent interlayers and back-painting might produce a material more similar in appearance to structural glass.

The replacement of 1-3/4" freestanding laminated partitions, such as those used in lavatories, poses a special problem because most in-kind replacement materials are thinner. The use of solid-surfacing materials, such as those used for present-day counter tops, if polished, has also been suggested. Once again, color (solid black is currently unavailable) and reflectivity are issues. Another substitute material that has worked in some cases is colored or back-painted polycarbonate sheets. Of the "plastic" materials—Lucite, Plexiglass, and Lexan—the latter is a polycarbonate and reportedly the least susceptible to scratches.

Conclusion

To conclude, there are no perfect substitutes for historic structural glass. Good maintenance of existing facades and safeguarding extant stockpiles are of great importance to the future survival of this endangered material.

Notes

1 The Czechoslovakian structural glass is available as follows: colors—black, white, beige, and mint green; thickness—approximately 1/4 inch; source—Floral Glass and Mirror, 895 Motor Parkway, Haupauge, New York, telephone 800-647-7672 or 516-234-2200.

2 The two Japanese structural glasses are available as follows. Japanese opaque structural glass: product name— Neoclad; colors—white, beige, and gray; thickness—0.5mm to 7.5mm; source—NEG America, Inc., 650 East Devon, Suite 110, Itasca, Illinois 60143, telephone 800-733-9559. Japanese structural glass: product name—New Sunprito; colors—white and light gray; thickness—5mm to 9mm; manufactured by ASAHI Glass Company; source The Sentinel Group, PO Box 399001, Miami Beach, Florida 33139, telephone 800-827-7848.

Carol J. Dyson is an architect with Preservation Services, Illinois Historic Preservation Agency, Springfield, Illinois.

Floyd Mansberger is the Director of Fever River Research, Springfield, Illinois.