Active Glass Walls: A Typological and Historical Account

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Active Glass Walls: A Typology

This paper provides a summary analysis of the typological and historical development of active glass walls. From the beginning of the glass revolution, the fascination with large areas of transparency has been tempered by the negative environmental effects they can produce: excessive heat loss when it is cold, excessive heat gain when the sun shines, and even excessive daylighting. These problems were already recognized by the glazing pioneers of the nineteenth century, and it was apparently Jean-Baptiste Jobard in 1849 who first imagined that the air between the layers of glass could itself be heated or cooled and so modify the effects of large glass walls. In 1914, Paul Scheerbart, the visionary author of *Glasarchitektur*, cautioned against that practice, arguing that "convectors and radiant heaters should not be put between the two skins [of glass] because too much of their output will lost to the outside air," and so began nearly a hundred years of experimentation and dispute about heating, cooling, or moving the air in glass walls.[1] The technique was picked up a few years after Scheerbart by Le Corbusier, who called it a "neutral wall", and then by many others in the decades after the second world war as glass curtain walls became a normative form of construction.

In recent decades, the numbers and variety of active glass walls have exploded, initially in northern Europe, but increasingly in Asia and the Americas as well. Some of the more common terms of designation are "double glass facades," "climate walls," "air-extract windows," intelligent facades," and "multiple skin facades," and while there are some distinct classes of these walls, the proliferation of types and of categorizations can make the field difficult to understand. In Dirk Saelens's simple definition, active glass walls are an "envelope construction, which consists of two transparent surfaces separated by a cavity, which is used as an air-channel."[2] That definition excludes atria, greenhouses, trombe walls, glass corridors, and insulated glass units, but does allow for many varieties of glass curtain walls with different kinds and amounts of glazing and different kinds and amounts of ventilation. Building on Saelens's analysis, there are four basic typological features of active glass walls:

- **Natural or Mechanical:** The first distinction among classes is whether the air cavity is ventilated naturally or mechanically, and the two classes are even discussed and analyzed separately. It is much more difficult to analyze the behavior of naturally ventilated walls, and like the distinction between "soft and hard" energy paths, the naturally ventilated walls are often considered to have inherent "natural" virtues.
- **Air Flow: Supply, Exhaust, or Air Curtain**. The second distinction is the source and destination of the air, leading to three possibilities: Outdoor air flows through the cavity into the building, indoor air flows through the cavity to the outside, and a recirculating air curtain or interior or exterior air.
- **Compartmentation: Facade, Shaft, Corridor, Window or Box.** The air cavity can be limited to a single window or box; or it can be extended horizontally in corridors, vertically in shafts, or across an entire facades allowing for different degrees of air flow and interconnection. Natural ventilation often relies on thermal buoyancy effects and so requires tall shafts or facades to provide substantial air flow.
- **Shading**. The air cavity is also a useful and popular place to located different forms of shading, typically a form of adjustable, horizontal louver to block unwanted sunlight from entering the building which can also generate the heat to produce the stack effect for natural ventilation.

Mode Switching. In addition to basic typological distinctions, active glass walls can employ different kinds of mode switching, increasing even further the types and characteristics of active glass walls. Changing the air stream from supply to exhaust or raising and lowering shades, allows the wall to accommodate different seasons and climactic conditions.

Basic Types

While there are many possible configurations have been proposed and built, the majority fall into three broad classes or types.[3]

- **Mechanical Air-Extract.** Inner layer sealed, single glass. Outer layer double glass, sealed.
  can involve mode switching from air curtain to exhaust
- **Natural Air-Curtain.** Inner layer sealed, double-glass. Outer layer single glass, sealed.
  can involve mode switching from air curtain to exhaust
- **Natural "Twin-Face."** Inner layer operable, double glass. Outer layer single glass, vented,
  can involve mode switching from air curtain to supply to exhaust

Each of these three types provides a thermal buffer space, shielding the inner glass wall in different ways from extreme environmental conditions. In general terms, the inner layer of glass is itself doubled in the natural air-curtain or the natural twin-face, while the exterior layer is doubled in the mechanical air-extract. In some variants the exhaust stream from the wall can itself be used to heat other parts of the building or the temper the input stream to the HVAC system, but in effect the different varieties provide the buffer space to accommodate different performance criteria.

In the literature describing their active glass wall products, Permasteelisa recommends the mechanical air-extract type for colder climates and the natural twin-face type for temperate or tropical climates, suggesting the limitations of simple cavity ventilation for cooling.[4] In both types, it is generally assumed that they will require mode switching from heating to cooling modes. In that operation, the mechanical air curtain is switched automatically by the HVAC system, while the natural twin-face is switched or opened manually by occupants. This raises the quite complex question of performance evaluation, since the use of such walls is explained according to many different criteria and compared to quite different base cases.

Performance Criteria.

There are a variety of performance criteria, and claims, by which active glass walls are presented.

- **Energy efficiency** by reducing the heating and cooling load of the glass wall
- **Comfort** through the interior temperature of the glass
- **Natural ventilation**, especially in the windy conditions of high rise construction
- **Acoustic separation** in noisy urban areas

Energy efficiency claims are discussed separately in the paper by Ali Malkawi and Yun Kyu Yi, but it is still difficult to objectively analyze the performance of most active glass walls. They appear to perform best in heating conditions, when the buffer space can be kept above the outside temperature, and there is little evidence that they regularly do well in conditions that demand cooling. The popularity of the natural "twin-face" walls in northern Europe can be partly attributed to the milder summer cooling climate they experience as opposed to the hotter, more humid conditions in Asia and North America. Moreover, many of the arguments for active glass walls rest instead on the provision of comfort, natural ventilation, and acoustic separation.

The performance questions about active glass walls are very similar to the discussion about brise-soleil in the 1950s, when exterior shading devices were effectively competing with high-performance, heat absorbing glass to control the overheating of the new glass curtain walls. Olgyay and Olgyay elegantly summarized the situation, arguing that visible sun-control devices were more architectural, meaning more visible and more expressive.[5]

Architectural Concepts

Despite the apparent objectivity of the performance criteria, the different types of active glass walls are often understood and selected for much more complex and architectural reasons than simple performance. These are most evident in the historical development of the walls.

Neutral walls. The modern history of active history of active glass walls begins with Le Corbusier's "neutral wall" (*murs neutralisant*) in the early 20th century. Beginning with the *Villa Schwob* built in 1916 in the extreme heating environment of the Swiss alps, Le Corbusier began to experiment with the insertion of heating pipes between large layers of glass. He proposed it for a number of projects through the 1920s, but only realized it in the Double House at Weissenhof Seidlung in Stuttgart in 1927.[6] As he described it at the time,

> How, you ask, does your air keep its temperature as it diffuses through the rooms, if it is forty degrees above or below zero outside? Reply, there are *murs neutralisants* (our invention) to stop the air at 18C undergoing any external influence. These walls are envisaged in glass, stone, or mixed forms, consisting of a double membrane with a space of a few centimeters between them. . . a space that surrounds the building underneath, up the walls, over the roof terrace. … In the narrow space between the membranes is blown scorching hot air, if in Moscow, iced air if in Dakar. Result, we control things so that the surface of the interior membrane holds 18C. And there you are.[7]

Those projects and his publications inspired imitators, Frederick Kiesler among them, but in 1931, Le Corbusier arranged with the St. Gobain glass to build a test cell of the configuration and they concluded that although "warming the air between the panes increases the sensation of comfort," it increases energy loss.[8]

Climate shift/Health. In 1937 William Lescaze built an elaborate double envelope house outside in the Catskills for Alfred Loomis. As he described it at the time, "the fundamental scheme of the house was dictated by the owners desire to experiment with a novel system of heating and air conditioning, in an effort to approximate the temperature and humidity condition of his South Carolina home."[9] The 2 foot wide air space was conditioned by a separate system from the house itself, and the conditioned buffer space allowed the inner house to maintain higher humidity levels without condensation on the inner glass. Loomis was the son of the founder of one of the Catskills tuberculosis sanitaria and evidently understood the climate shift in terms of health.

Comfort. In the 1950s the mechanical extract-air wall was developed in Scandinavia to improve the thermal experience of large glass areas, particularly in extreme heating conditions. It was variously known as the air-extract window, air-curtain window, or a climate window.10 By drawing conditioned room air between the panes of double or triple glass, the inner glass layer reaches a temperature close to that of the room, reducing the radiant discomfort produced by large areas of glass in winter.

Energy efficiency. Beginning in the 1970s, the focus of double walls shifted to energy efficiency. A variety of new and modified forms were developed specifically for energy purposes and often conceived as solar collectors. Two well known examples in the US were the Occidental Chemical Company building in Niagara Falls, NY, completed in 1981 by Cannon Design and Prudential's Enerplex North by SOM, designed in 1979.[11]

It seems to have been this period when the distinction between natural and mechanical ventilation received a sharper focus, characterized in the opposition between active and passive solar designs. For active glass walls, that opposition was characterized in the difference between the re-definition of the Scandanavian air-extract window as a solar collector and the controversial, natural-flow double-envelope houses.[12]

Natural ventilation. With the proliferation of active glass walls across northern Europe through the 1990s, the natural twin-face configuration has been developed and refined with a great emphasis on direct natural ventilation of interiors and improved sound insulation. Perhaps the best-known of these very elegant buildings was Norman Foster's Commerzbank built in Frankfurt in 1997, designed according to the principle that each occupant should be afforded natural light, natural ventilation, and a view of greenery, and all individually controlled.

Conclusion

This paper has summarized the basic typological features and characteristic configurations of the active glass walls that have become so popular in recent decades. Through an historical account of their development, I have tried to make the simple point that such walls are conceived and deployed according to complex architectural concepts, and not only performance criteria. Like the external sun-shading facades of the 1950s, active glass walls are implicitly competing with the progressive refinements of high-performance glass assemblies that can deliver similar performance at lower cost.

Active glass walls can be understood as a specific result of the 75 years of encounter between traditional building elements—walls, floors, ceilings, windows—and mechanical environmental technologies. And though that period, each of the traditional architectural elements has been invaded by pipes, wires, and ducts, yielding new hybrid forms of construction such as raised floors and plenum ceilings. But why do we not find raised floors or plenum ceilings as interesting or exciting? Like active glass walls, both of these are traditional architectural elements that have been activated by the introduction of an internal air stream. Unlike the plenum spaces above ceilings, below floors, or in building cores, the flow of "conditioned" air in glass walls excites an enthusiasm that exceeds any performance claims. The difference, of course, is that active glass walls are transparent, revealing and concealing the HVAC operations that they facilitate.

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