The Curtain Wall in Architectural Education: Technology, History and Design

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INTRODUCTION

Recent years have seen a rapidly growing interest among contemporary architects in the innovative use of custom prefabricated curtain walls as building enclosure (see Fig. 1), leading to a new level of sophistication in the design and construction of these systems. As a versatile and nearly ubiquitous technology, the curtain wall is increasingly shaping not only the appearance and character of our cities, but also the performance of buildings with respect to energy efficiency and occupant comfort.

As architects continue to investigate the curtain wall as a site for design innovation, how can we address this topic in architecture schools to expose students to the range of research and development currently taking place in practice? How can we prepare students to participate in the design process in an informed and meaningful way? This paper presents the structure and outcomes of an ongoing seminar course at the University of Illinois which approaches the design of curtain walls not merely as a technical solution or a design aesthetic, but rather as a process that potentially integrates knowledge of technology and design, as well as the rich history of the curtain wall in modern architecture. It is an ideal topic in which to engage the teaching of technology through design.

A HISTORY OF TECHNICAL AND DESIGN INNOVATION

> "The contribution of the present age is that it is now possible to have an independent wall of glass, a skin of glass around a building; no longer a solid wall with windows. Even though the window might be the dominant part—this window is the wall itself, or in other words, this wall is itself the window. And with this we have come to a turning point… it is the disappearance of the outside wall."[1]
>
> -Arthur Korn, 1929

The curtain wall can be defined most broadly as a non-loadbearing exterior wall enclosure which is supported by the building structure. It typically consists of a framework system which can incorporate numerous variations in materials, form and function. Modern architects' initial fascination with the curtain wall was based on the possibility of maximizing transparency through increased use of glass, following the development of the frame structure in the late nineteenth century. Commenting in 1922 on the relationship of structure and transparency, Mies van der Rohe wrote that

> "we can see the new structural principles most clearly when we use glass in place of the outer walls, which is feasible today since in a skeleton building these outer walls do not actually carry weight. The use of glass imposes new solutions."[2]

In the following decades, the ideal of transparency became increasingly real as advancements were made in manufactured curtain wall components, especially architectural glass production (including the development of double-pane insulating glass unit in the 1930s and the invention of the float glass manufacturing process in the 1950s). In the 1950s and 60s, the rise of the "glass box" phenomenon, initiated by the success of buildings such as SOM's Lever House and Mies's Seagram Building, defined modernism—and spurred an eventual backlash, or critical reconsideration of the typical mid-century curtain wall.

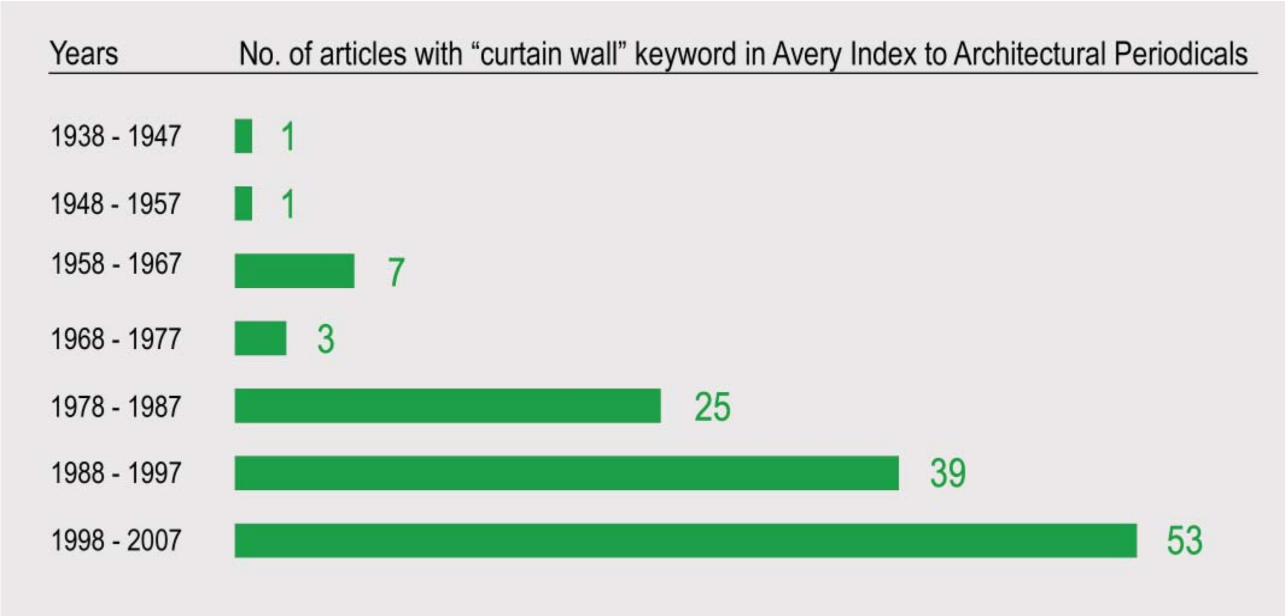

Figure 1. This graph illustrates the increasing prevalence of the curtain wall as a topic of architectural discourse. The Avery Index, a program of the Getty Research Institute, is a comprehensive guide to US and foreign journals focused on architecture and design.

In recent decades, an evolution of the concept of the thin, transparent wall into something more substantial has taken place. In their 2003 book *Tower and Office*, the architects Iñaki Ábalos and Juan Herreros describe this transformation of the glass building skin from a passive to an active system, writing that the curtain wall is now "the site at which glass, climate control, and the external environment assume congruent and interactive roles."[3]

From the early visionary projects of architects such as Mies van der Rohe in the 1920s and the proliferation of the modernist glass box aesthetic in the 1950s and 60s to the currently emerging rise of multi-layered 'intelligent' facades, the curtain wall has played an important role in the history and development of modern architecture. Just as the advent of the frame structure in steel and reinforced concrete freed the exterior wall from its load-bearing responsibilities over a century ago, the concept of the curtain wall freed the architect to imagine new paradigms for the building envelope.

THE CURTAIN WALL IN CONTEMPORARY PRACTICE

As a component of contemporary architectural practice, the field of curtain wall design certainly encompasses technology, for the curtain wall is primarily a technical response to the phenomenon of the frame structure, expected to achieve a specified level of performance. But it is also much more than this. For many architects, the building envelope represents the most fertile ground for design innovation related to material expression and performance. In a 1997 Architecture magazine article on custom curtain wall design, the curtain wall is identified as "an architect's most substantial design outlet," the part of the building design where architects take their most creative liberties."[4] Today, with increasing concerns for sustainability and energy efficiency, architects view the curtain wall as an opportunity to combine cutting-edge aesthetics and high-performance technology. This is perhaps most apparent in the recent rise in double-skin curtain walls and the innovative use of shading devices and photovoltaics in the building envelope. In such systems, the goal is to control the flow of energy in both directions (inward and outward), to maximize internal comfort while minimizing energy usage. The main components typically include a double-skin glass envelope with variable sun-shading or diffusing elements and operable ventilators, and can also include power-generating components such as photovoltaic cells or wind turbines. These new façade systems are often integrated directly with the building's mechanical system to create a holistic, efficient building response to climate and energy.

The design of curtain wall systems is influenced by a broad range of issues—from materiality and aesthetic effects to technical and performance concerns. What materials can be used in curtain walls? How are these materials manufactured, and in what dimensions? How are curtain walls designed for the desired level of performance? How are they tested, fabricated and installed? How do they perform once installed? For a student of architecture, the design of a curtain wall system can seem a complex and mystifying proposition. But through studying the specific design and construction processes of these systems, students not only improve their own design work but also leave school better prepared to engage as professionals with this growing aspect of the field.

THE CURTAIN WALL SEMINAR: TECHNOLOGY + DESIGN

As part of the M.Arch. program at the University of Illinois, I teach a seminar titled "Curtain Wall Design & Construction," which is focused on preparing students to take part in this interesting, expanding discourse within contemporary practice. In addition to studying the historical development of curtain walls and the materials, design principles, and fabrication techniques associated with them, each student conducts a case study research project in which they become an 'expert' on the enclosure system of a notable, recently completed building, and each student completes a final design project in which he or she applies knowledge gained throughout the semester.

The seminar format was chosen to ensure a reasonable class size and to maximize interactions between the teacher and each student. The course is linked to the design studio and the design thesis by encouraging students to use a current design project as the vehicle through which they explore curtain wall concepts. The seminar is organized into three related phases:

Phase 1: a series of presentations, readings and discussions covering a range of fundamental issues. Topics include an historical overview; typology and principles of design; materials; fabrication; performance criteria; curtain wall documentation, testing and inspection; and areas of future development.

Phase 2: Case Study Project. Each student researches and documents the curtain wall system on a recent building, selected from a list provided by the instructor. Students present results in drawing and written format and lead discussions about their research.

Phase 3: Final Design Project. Each student designs, develops, and details a custom curtain wall system of his or her own design. The focus of the project is the design of the exterior skin, addressing both aesthetic and technical issues. In consultation with the instructor, students choose a site, program, and building form for which they will develop a custom enclosure system, incorporating principles learned during the semester. A current or past studio project may be chosen.

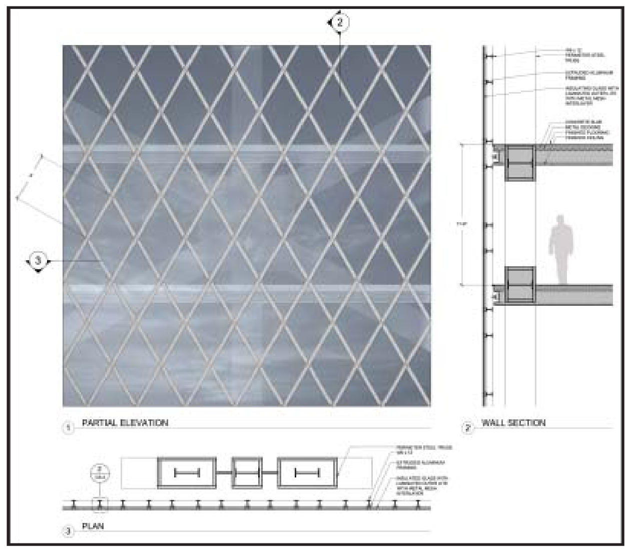

Figure 2. Student project (Case Study: Seattle Central Library by OMA/LMN). The composite elevation/section/plan drawing is a key method used to explore the case study and must integrate aesthetic and technical representation.

The case study buildings are selected for a variety of reasons: innovative use of materials, unique geometries and/or exemplary high performance. The architects selected are generally considered design innovators, but the students soon learn that successful design requires technical mastery. The Case Study Project is guided by the principle that architectural drawing is a form of research, and that the most informative drawings address technical as well as aesthetic issues. Each case study is documented in drawings and renderings completed by the students, presented to the class and publicly exhibited as a tool for broader discussion within the school of architecture. Research includes general information about each building, site, and architect, but is focused on an intensive study of the building skin itself. For consistency, a standardized format is used, a key component of which is the detailed plan-section-elevation composite sheet, in which a selected portion of the façade is drawn aligned with a wall section and floor plan. These drawings (examples of which can be seen below) are presented at the same scale to allow for direct comparative analysis from project to project. The elevation drawings are intended to eschew abstraction in favor of a realistic depiction of the actual appearance of the materials on site. To successfully complete these drawings, students must answer a number of questions: What are the sizes and thicknesses of the various component materials? What is the relationship (if any) to the human scale? How do issues of program, site, and context inform the design? How is the system connected to the building structure? Important details are also identified and explored in drawings and models at a larger scale in 2D and 3D representations. These typically include assembly and connection details and thermal modeling. Through this process, the class develops a body of knowledge about issues in contemporary curtain wall design, demystifying a complex but important topic. Following the case study project, in the final phase of the course students apply their new knowledge of curtain wall systems to their own final project, now undertaking their designs with a fuller understanding of the materials and processes of curtain wall design and fabrication.

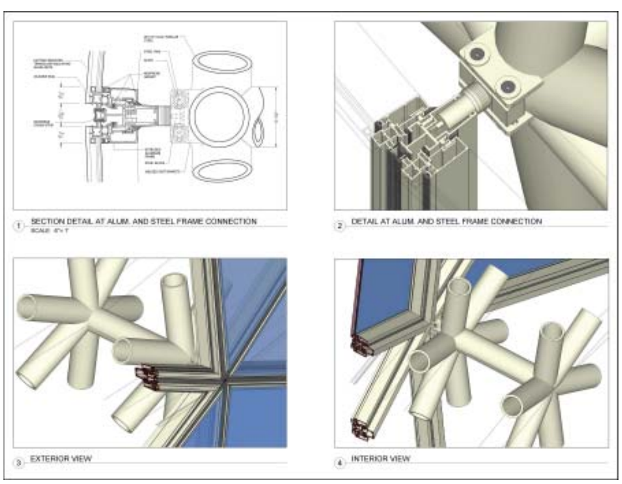

Figure 3. Student project (Case Study: Cambridge Law Faculty by Norman Foster). Students complete curtain wall detail drawings in both 2D and 3D to understand components and assembly.

EXAMPLES OF STUDENT WORK

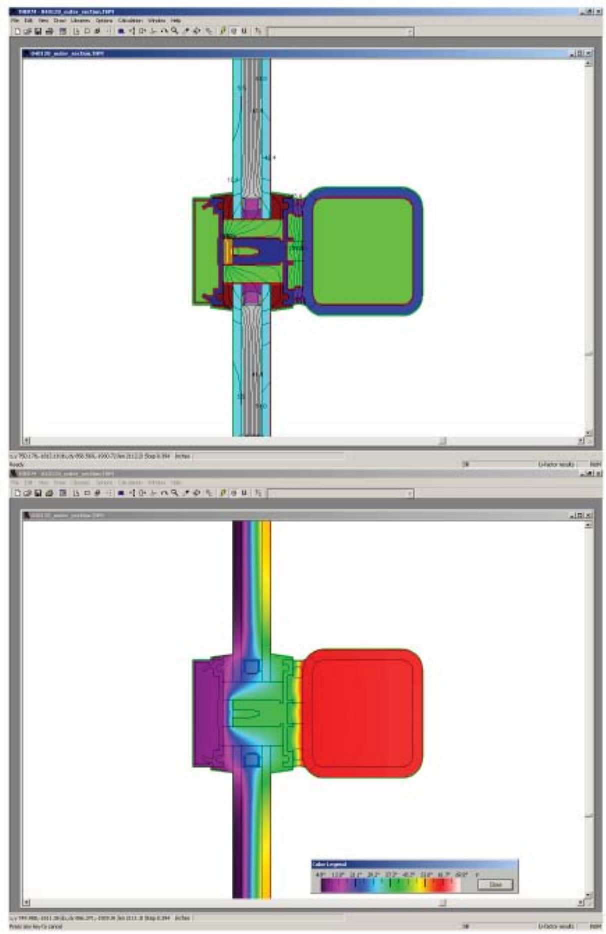

Figure 4. Student project, mullion detail. Students use simulation software, including THERM 5.0, to study relationship of materials, detail and performance.

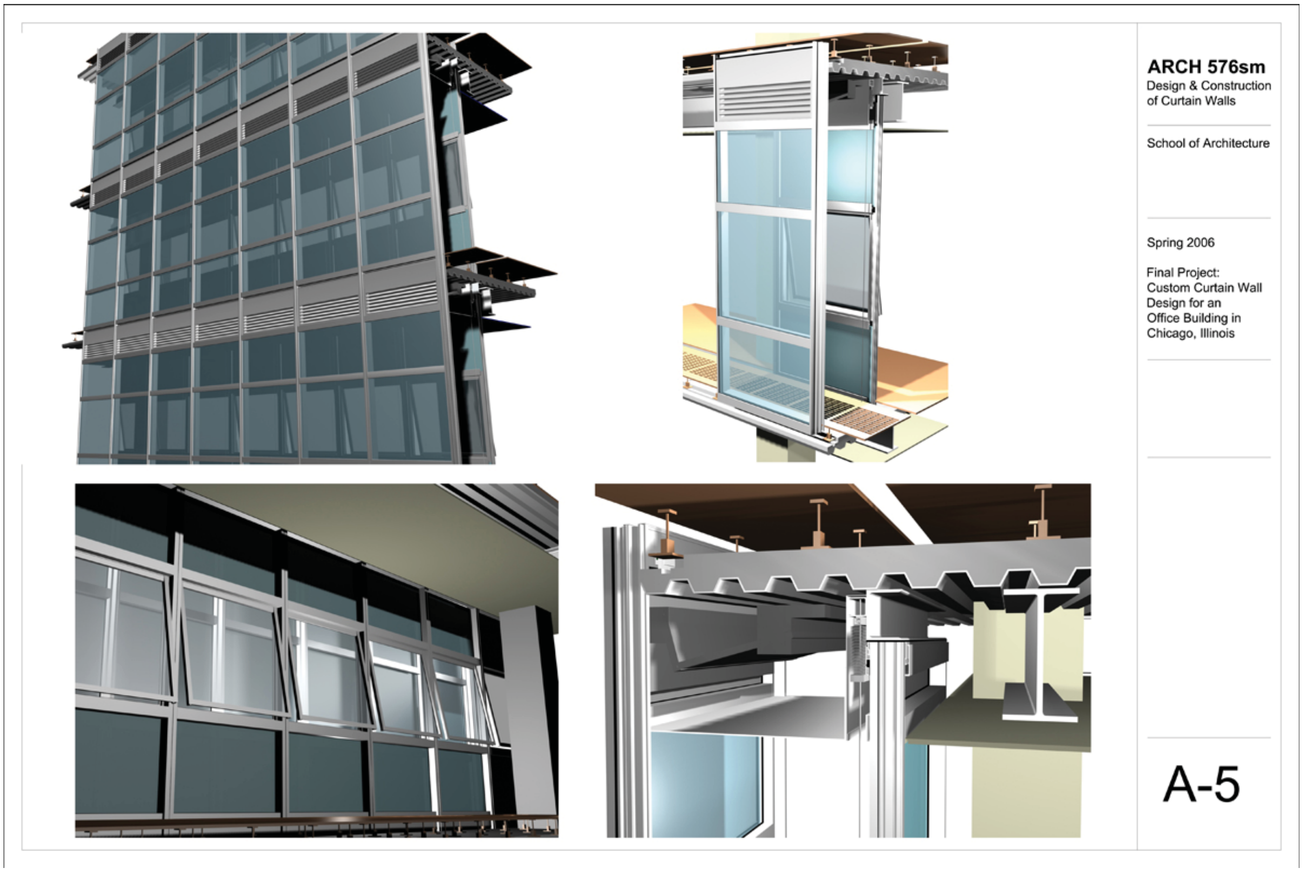

Figure 5. One sheet from a final project presentation; custom double-skin curtain wall system designed and detailed by the student.

ENDNOTES

1. Arthur Korn, *Glass in Modern Architecture of the Bauhaus Period* (New York: George Braziller, 1968), 6. First published in German under the title *Glas im Bau und als Gebrauchsgegenstand* in 1929.

2. Ludwig Mies van der Rohe, *Fruhlicht* (1922), as translated in Peter Carter, *Mies van der Rohe at Work* (London: Phaidon Press Limited, 1999), 18.

3. Iñaki Ábalos and Juan Herreros, *Tower and Office: From Modernist Theory to Contemporary Practice* (Cambridge, MA: MIT Press, 2003), 40.

4. Anne C. Sullivan, "Customizing the Curtain Wall," *Architecture* (January 1997), 124.