INVESTIGATION III: CURTAIN WALL REDESIGN
MECHANICAL AND ACOUSTICS BREADTH STUDIES
PURPOSE OF INVESTIGATION

Originally investigated in an effort to minimize the delays to the construction schedule, the curtain wall system of the Elliott School of International Affairs was also analyzed to increase occupant comfort by utilizing the emerging technology of a dual-layered glass façade. The intent of the proposed curtain wall system redesign was to improve the environment within the academic office spaces located along the building’s south façade and produce a more energy efficient structure, without sacrificing any of the original design intent.

EXISTING STICK CURTAIN WALL SYSTEM

The metal-and-glass curtain wall constructed as an element of the Elliott School of International Affairs complex building envelope consisted of double glazed standard and spandrel glass panels contained within aluminum framing components. As illustrated above, the curtain wall covers an area of nearly 9,500 square feet of the buildings south façade, with the remainder being comprised of a combination of granite panels, precast concrete panels, metal-and-glass storefronts, and standard double glazed windows.

The curtain wall system’s design utilized standard components developed and manufactured by Vistawall, an industry leader in the design and manufacturing of engineered wall systems.

The drawing on the following page illustrates how a precast panel wall system and the metal-and-glass curtain wall comprise the perimeter walls for the office spaces along the Elliott School’s southern elevation. The curtain wall spans from floor-to-ceiling within the office spaces, with upper and lower spandrel glass panels and a clear glass center panel. Fin tube radiation was installed within the framing components of the curtain wall system to prevent convection heat loss through the building envelope.
PROPOSED DUAL-LAYERED GLASS FAÇADE

Investigation of alternative curtain wall systems, specifically unitized systems, progressed from standard unitized systems similar to the installed stick-system and also manufactured by Vistawall, to the developing technology of double-skin glass curtain walls. Due to interest in the emerging technology as well as sustainable design and construction, a dual-layered glass façade was proposed and analyzed as an alternative to the existing metal-and-glass system.

The dual-layered glass façade is a European architectural phenomenon driven by the desire for an all-glass building façade without sacrificing indoor air quality while addressing the growing concern of energy conservation. Prevalent throughout Europe and Asia, dual layered glass facades are gaining popularity in the United States with the emergence of environmentally conscious design and construction—specifically that endorsed by the LEED (Leadership in Energy and Environmental Design) Green Building Rating System.

Double-skin curtain walls vary greatly in their application, size, and mechanical operation. In a typical double-skin curtain wall, an air cavity—measuring a few inches to multiple feet—is created by adding an additional layer of toughened glass behind the standard double glazed glass unit. A sun shade device, typically louvered blinds, is placed within the air cavity to control sunlight as well as heat gain. Various means of ventilating the air cavity exist, with the proposed system being mechanically ventilated. Lower pressure within the cavity draws in a portion of the room’s return air, where it is warmed by the solar radiation absorbed by the sun shades. The air is then drawn out of the cavity mechanically and returned to the building’s HVAC system. In months requiring heating, solar energy can be recovered from the system by utilizing heat exchangers.
The proposed system, illustrated below, is based upon the ‘standard’ double-skin curtain wall manufactured by Permasteelisa Cladding Technologies, Ltd. and utilized on the Levine Hall School of Engineering and Applied Sciences at the University of Pennsylvania. Permasteelisa’s tested and applied Active Wall™ system is readily available from the Italian manufacturer’s American headquarters—based in Connecticut. The relatively standardized system is designed and manufactured to meet a project’s specific architectural and mechanical requirements, and is fabricated and installed as a unitized curtain wall system.

![Proposed Curtain Wall System](image)

**FIGURE 19** Proposed Curtain Wall System

### PERFORMANCE OF PROPOSED DUAL LAYERED GLASS FACADE

#### Architectural

The aesthetic intent of the original architectural design of the Elliott School is maintained in the proposed dual-layered curtain wall. Permasteelisa manufacturer’s the proposed Active Wall™ system in conjunction with the requirements—both mechanically and architecturally—of each specific project. The relative size of the rails and mullions of the existing stick-system can be applied to an Active Wall™ system, creating a mechanically superior curtain wall which maintains the original aesthetic design.

Within the interior spaces of the structure, the redesign of the curtain wall also has a minimal impact on the original design. Because the air cavity and second layer of glass required of the dual-layered façade is added within the extent of the existing system’s framing components, the intended individual space and total building square footages were maintained.

#### Mechanical

The proposed unitized curtain wall works in conjunction with the Elliott School’s mechanical system, helping to maintain occupant comfort by using the cavity between the inner and outer glazing as a plenum through which return room...
air is circulated— as illustrated below. The cavity also houses mechanical blinds. In periods with solar radiation, energy is absorbed by the blinds and removed via the ventilated air.

During periods requiring a heating load, the solar energy absorbed by the blinds and removed via ventilated air can be recovered by means of heat exchangers. However, the proposed redesign does not include the addition of heat exchangers to the Elliott School's mechanical system for heat recovery, but instead focuses on the thermal insulating properties of the Active Wall™.

![Diagram of Active Wall™ System and Components](image)

**FIGURE 20** Permasteelisa's Active Wall™ System and Components (Permasteelisa Cladding Technologies, Ltd.)

Improved occupant comfort— especially at locations near the exterior wall—results from the proposed dual-layered glass façade. Manufacturer supplied thermal transmittance values of the proposed curtain wall systems show that the U-value of the exterior wall is 0.100 BTU/HR°F, while the existing curtain wall system has a U-value of 0.625 BTU/HR°F. Due to the increased insulating properties of the proposed system, as well as the return air circulating through wall cavity, the temperature of inner glass surface of the system is maintained within two degrees of the temperature of the room air.

The fin tube radiators installed in conjunction with the existing system work to wash the interior surface of the windows with heated air in an effort to raise the temperature of the inner surface to that of the room air. The proposed system dramatically reduces the Elliott School's envelope load from 2968 BTU/HR to 543 BTU/HR— as illustrated in Appendix D, on Page 64 — maintaining air and surface temperatures at the perimeter consistent with the remainder of the space, allowing for the fin tube heating units positioned along each segment of the existing curtain wall to be removed.

Eliminating the nearly one hundred fin tube radiators, also allows for the reduction in the size of the Elliott School's gas fired boiler. The 2000 MBH
boiler can be reduced to a 1200 MBH boiler, as illustrated by the calculations in Appendix D, on Page 65.

The removal of the fin tube radiators and reduction of the gas fired boiler creates a more efficient mechanical system for the Elliott School of International Affairs. By reducing the heating requirements of the system, energy is conserved and the associated supply and operating costs are reduced.

**Acoustical**

The southern façade of the Elliott School of International Affairs sits along the traffic congested four outbound lanes of E Street in the heart of Northwest Washington, DC near the entrance ramp of the E Street Expressway. The E Street Expressway feeds the Woodrow Wilson Bridge and the George Washington parkway, acting as a major means of exiting the District of Columbia.

The proposed dual-layered glass façade improves upon the sound insulating properties of the existing double glazed system. Data obtained from Permasteelisa indicates an STC Rating of 40 for the proposed Active Wall™ system, while the STC Rating of the existing curtain wall measures 32. The STC, Sound Transmission Class, Rating of a construction assembly is a single number, calculated by fitting a standard contour to transmission loss data, rating the effectiveness to retard the transmission of airborne sound. A higher STC Rating corresponds to greater sound insulation.

An STC Rating of 40 is considered very high, especially for a complete curtain wall assembly. While glass alone in a standard size might provide an STC Rating of 40, when combined with framing components, its insulating effectiveness typically decreases substantially.

Although the proposed system contains a substantial air cavity, the problems of flanking—lateral sound transmission—are avoided, since the curtain wall components of each office space are horizontally and vertically independent from the others. This horizontal and vertical separation also works to avoid fire and smoke transmission between interior spaces.

**Lighting**

The amount of window area remains relatively unchanged from the original architectural design; therefore the levels of natural light intended for interior spaces are maintained.

The existing system utilizes motorized shades mounted in a cavity in a bulkhead constructed along the exterior walls. The shade system is replaced by the mechanically controlled louvered blinds. The blinds are fully adjustable, allowing for full shading or visibility, providing greater and more varied occupant control of the light entering each space. The blinds are unobtrusive to the external appearance of the building and require minimal maintenance.
Structural

The proposed curtain wall system is anchored to the Elliott School's structural system at each cast-in-place floor slab via site attached cleats. The existing edge beams at the structure's southern perimeter support a combination of the existing curtain wall and precast concrete panels. Although not specifically analyzed, it is assumed that the added weight of the proposed system is not significant enough to require structural support beyond that which was constructed.

Conclusions

Application of the Active Wall™ curtain wall system to the Elliott School of International Affairs construction project creates a greatly improved environment within the academic offices along the building perimeter without sacrificing any of the project's original design intent.

The U-value of the proposed system is nearly one-sixth that of the existing system. This dramatic improvement of the insulating properties of the building envelope allows for the fin tube radiation along the building perimeter to be eliminated. The removal of the fin tube radiation allows the Elliott School's gas fired boiler to be reduced in capacity, increasing the efficiency of the building's mechanical system and providing energy savings.

The proposedActive Wall™ system also increases the acoustical insulating properties of the building envelope. The proposed Active Wall™ system has an STC Rating measured to be 40, while that of the existing system is measured to be 32. With the academic offices looking out on traffic congested E Street in Northwest DC, improving the sound insulation will minimize the distractions of exterior noise.

### Table 4 Curtain Wall System Performance Comparison

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Existing DGU Wall</th>
<th>Proposed Active Wall™</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-Value (BTU/Hr°F²/F)</td>
<td>0.625</td>
<td>0.100</td>
</tr>
<tr>
<td>STC Rating</td>
<td>32</td>
<td>40</td>
</tr>
</tbody>
</table>

Improving the environment within the Elliott School does not come as a result of sacrificing the architect's original design intent for the project. The proposed curtain wall can be fabricated to appear nearly aesthetically identical to the existing DGU wall. The proposed wall is able to be constructed within the extents of the existing curtain wall frame, allowing the building and individual space square footages to be maintained. Also, the proposed curtain wall does not alter the amount of daylight provided to the spaces, but instead allows for greater individual control via mechanically louvered blinds.
APPENDIX D: CURTAIN WALL REDESIGN - MECHANICAL BREADTH

- ENVELOPE LOADS
- BOILER REDUCTION
- COST SAVINGS
## CURTAIN WALL SYSTEM ENVELOPE LOADS

### TABLE D.1 Precast Panel Wall

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>R-VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside Surface</td>
<td>0.69</td>
</tr>
<tr>
<td>0.625&quot; Gypsum Board</td>
<td>0.56</td>
</tr>
<tr>
<td>2.5&quot; Metal Studs</td>
<td>0.91</td>
</tr>
<tr>
<td>2.5&quot; Rigid Insulation</td>
<td>8.01</td>
</tr>
<tr>
<td>0.5&quot; Air Space</td>
<td>0.91</td>
</tr>
<tr>
<td>6&quot; Precast Panel</td>
<td>2.02</td>
</tr>
<tr>
<td>Outside Surface</td>
<td>0.33</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>13.43</td>
</tr>
</tbody>
</table>

### TABLE D.2 Existing Wall System Envelope Load — Heating

<table>
<thead>
<tr>
<th>EXISTING CURTAIN WALL</th>
<th>U-VALUE</th>
<th>WALL AREA (FT²)</th>
<th>°T</th>
<th>Q (BTU/HR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precast Panel Wall System</td>
<td>0.07</td>
<td>21</td>
<td>55</td>
<td>80.85</td>
</tr>
<tr>
<td>DGU Curtain Wall</td>
<td>0.625</td>
<td>84</td>
<td>55</td>
<td>2887.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>2968.35</strong></td>
</tr>
</tbody>
</table>

### TABLE D.3 Proposed Wall System Envelope Load — Heating

<table>
<thead>
<tr>
<th>PROPOSED CURTAIN WALL</th>
<th>U-VALUE</th>
<th>WALL AREA (FT²)</th>
<th>°T</th>
<th>Q (BTU/HR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precast Panel Wall System</td>
<td>0.07</td>
<td>21</td>
<td>55</td>
<td>80.85</td>
</tr>
<tr>
<td>Dual-Layered Curtain Wall</td>
<td>0.10</td>
<td>84</td>
<td>55</td>
<td>462</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>542.85</strong></td>
</tr>
</tbody>
</table>

- Design temperature and R-value data taken from the 2001 ASHRAE Handbook of Fundamentals, I-P Edition
- Active Wall™ U-Value provided by Permasteelisa Cladding Technologies
- DGU Curtain Wall U-Value provided by Ridgeview Glass
BOILER REDUCTION CALCULATIONS

Fin Tube Radiator Specifications
- 2070 BTU/Hr/Ft
- 7.48 GPM
- 3.5’ Length

Gas Fired Boiler Specifications
- 2000 MBH Input
- 86% Combustion Efficiency

\[ 2070 \text{ BTU/Hr/Ft} \times 3.5’ = 7245 \text{ BTU/Hr} = 7.245 \text{ MBH/Radiator} \]

\[ 7.245 \text{ MBH/Radiator} \times 98 \text{ Radiators} = 724.5 \text{ MBH Reduction} \]

\[ 2000 \text{ MBH} \times 86\% = 1720 \text{ MBH Maximum Output} \]

\[ 1720 \text{ MBH} - 724.5 \text{ MBH} = 995.5 \text{ MBH} \]

\[ 995.5 \text{ MBH} / 86\% = 1157.6 \text{ MBH} \rightarrow 1200 \text{ MBH Boiler} \]

Associated Cost Savings
- 1999 RS Means Building Construction Cost Data
- 1960 MBH Gas Fired Boiler: $26,700
- 1200 MBH Gas Fired Boiler: $18,100
- Washington, DC City Cost Index (Mechanical): 95.9
- 2000 Historical Cost Index: 119.6
- 1999 Historical Cost Index: 117.6

\[ $26,700 - $18,100 = $8600 \]

\[ $8600 \times .959 \times 119.6/117.6 = $8387.66 \text{ Total Adjusted Savings} \]
MECHANICAL SYSTEM SAVINGS

Table D.4 Mechanical System Savings

<table>
<thead>
<tr>
<th>ITEM</th>
<th>QTY</th>
<th>UNIT</th>
<th>TOTAL INCL O &amp; P</th>
<th>COST INCL O &amp; P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fin Tube, 2-3/4&quot; copper tube, 4-1/4&quot; alum. fin</td>
<td>343</td>
<td>lf</td>
<td>82.08</td>
<td>$28,153.44</td>
</tr>
<tr>
<td>Copper Piping, 3/4&quot;</td>
<td>900</td>
<td>lf</td>
<td>7.2</td>
<td>$6,480.00</td>
</tr>
<tr>
<td>Steel Shade Supports</td>
<td>785</td>
<td>lf</td>
<td>42</td>
<td>$32,970.00</td>
</tr>
<tr>
<td>Mechanically Operated Sun Shades</td>
<td>3780</td>
<td>sf</td>
<td>5.25</td>
<td>$19,845.00</td>
</tr>
<tr>
<td>Boiler Reduction</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$8,387.66</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td>$95,836.10</td>
<td></td>
</tr>
</tbody>
</table>

- Fin tube and copper piping costs were taken from 2000 RS Means Mechanical Cost Data
- Pricing for the steel shades supports provided by the project steel contractor, Baltimore Steel Erectors
- Pricing for the mechanically operated sun shades were provided by the project shade contractor, Sun Coast
- Pricing for the boiler reduction was calculated on the previous page