



Structurally Transparent Juxtaposition

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A new office complex in Washington, D.C., by Pritzker Prize winning architect Richard Rogers, bridges history and modernism with transparency. A novel glass atrium joins two historical buildings with a new modernist mid-rise, the shared space transforming the existing site into an integrated work environment. The atrium features a custom glass wall and roof, elegant by design and innovative in their responsiveness to the challenging constructability issues presented by a highly constrained building site, aggressive construction schedule, and a requirement for minimal disruption to the existing buildings, which were to remain operational throughout construction. The result breaks the mould of traditional Washington, D.C., office space, with modernist architecture and a strong connection to the immediate public realm enhancing this prominent street address.

1 INTRODUCTION

51 Louisiana and 300 New Jersey Avenue comprise a state-of-the-art office building project in Washington, D.C., located just one block from the U.S. Capitol. The project includes the construction of a new glass-enclosed office building (Figure 1) that will serve as an extension of two existing office buildings, all connected by a new centerpiece atrium (Figure 2). The challenging facade program that encloses the new 10-story atrium space includes a vertical entrance wall and glazed sky-light. A yellow tree-like steel construct provides the atrium structure, supports a trapezoidal flying roof of glass, and carries exposed HVAC and other building system components. Multiple levels of 16 glass skybridges tie the complex together. As all structure and systems are exposed, the highest level of craftsmanship was required for every aspect of construction. The project is the first office building by London-based Rogers Stirk Harbour + Partners and Pritzker Prize winning Principal Richard Rogers.

2 SITE CONTEXT

The pentagonal site is located within easy walking distance of the Capitol. Two existing buildings – one from 1935 and the other an addition from 1953 – possess a monumental, stone-clad, governmental aesthetic, while the new third building and atrium declare a bold, modern and transparent juxtaposition to fill out the site. Space was very limited on the dense urban site, and office buildings immediately adjacent to the site remained operational throughout construction. In addition to the general contractor, Clark Construction, over 40 subcontractors and an average of 200 site workers each day were involved in construction activities lasting over a 3-year period. Such tight constraints required intensive site logistics, collaboration, management, and coordination between trades to assure optimum workflow and minimal disruption to immediately adjacent building occupants.



Figure 1: View from the northeast of the office complex.

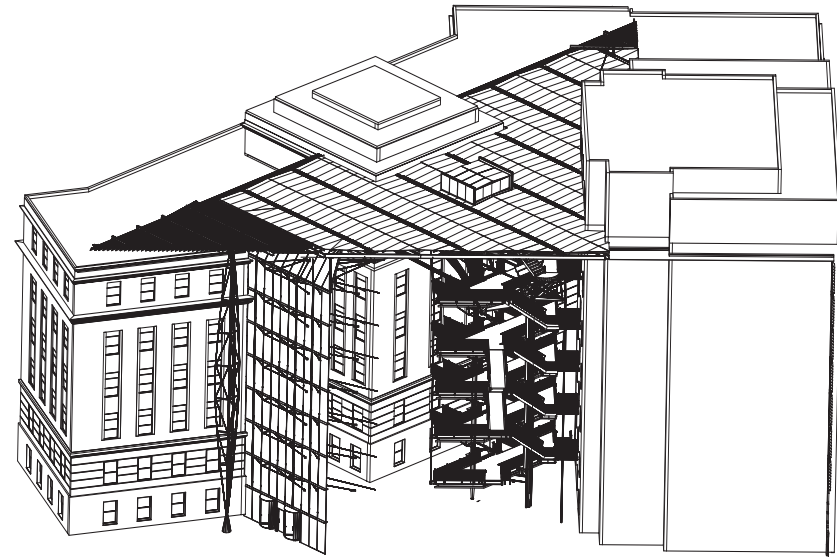


Figure 2: Model of the two existing structures and central atrium specialty glazing (new office structure omitted for clarity).



Figure 3: Atrium entrance wall with vertical and horizontal springs.

3 DESIGN

The custom glazing systems developed for the atrium wall and roof are minimalist solutions developed in specific response to the architect's aesthetic intent and constructability challenges presented by building program. The ability to anticipate and address constructability issues early in the design process contributed much to the ultimate success of this project.

3.1 Entrance Wall

The wall that forms the entry to the new complex climbs vertically over 90 feet and then slopes back nearly 14 feet to join the glass roof (Figure 3). A high level of transparency combined with a minimal but expressive structure was particularly important in the design of the glass wall. Another important design objective was to minimize loads into the existing buildings.

The entire entrance wall is hung from above, with a series of suspended horizontal trusses providing the minimal structure. Measuring 38 feet wide by 102 feet tall, the wall is framed with a series of horizontal “kipper” trusses fitted with 2-foot vertical armatures to hold in place the point-fixed laminated IGU panels. The term kipper was coined by the architect to describe the geometry of the truss. The horizontal truss consists of augmented steel W-sections, plate armatures, and tension rods. Out-of-plane bracing rods on the north end of each truss provide lateral stability, while spring mechanisms at the south end of each kipper truss were designed into the

structural system to absorb relatively high deflections and relative building movement without inducing high compressive stresses into structural components.

Vertical loads are accumulated at the top of the wall, transmitted through interior and exterior out-of-plane diagonal rods, and delivered to the adjacent building structure at the north edge of the wall. In essence, the entrance wall is hung from the adjacent new office building structure, minimizing loads to the existing building opposite. Stainless steel rods on both the interior and exterior of the glazing hang each sequential kipper truss from the one above. These vertical rods terminate at the entrance door header with a series of interior and exterior spring connections. The spring is slightly compressed and installed at the bottom terminus of the rods (Figure 3). Deflection of the glass facade will further compress the spring. In returning to its pre-deflection shape, the spring stabilizes the system.

Point fixings tie the glass to the trusses at the end of 2’ armatures extending above and below the trusses. Stainless steel clamp fittings penetrate the glass joint to capture the glass. The weather seal is provided by a field-applied butt-glazed silicone joint.



3.2 Sloped Wall

The transition between the vertical entrance wall and overhead skylight is achieved by a one story sloped skylight that is 14 feet long at an angle of 49° (Figure 4). The full-size glass lites are perimeter supported on aluminum frames. The insulated glass panels are tempered, with a ¼” outer lite, ½” airspace and ¼” x 5/16” laminated inner lite. The sloped portion is shaded by overhead aluminum louvers, which continue the skylight geometry beyond the entrance wall. A metal panel is placed within the sloped wall at the point of truss penetration and is designed to accommodate the structural movements without imposing loads on the sloped wall.

ladder frames are supported by the walls of the buildings at the perimeter of the skylight, as well as by a steel tree in the center of the gallery (in yellow, Figure 6).

In the vicinity of the 1935 building, a clere-story encloses the elevation difference between the new atrium and the existing structure. The glass and aluminum framing are consistent with the skylight design. The southwest and northeast corners of the skylight extend beyond the atrium to support overhead aluminum louvers. In the southwest corner, the extension is achieved by cantilevering the skylight framing. In the northeast corner, it is achieved with an external pipe mast and diagonal hanger braces (see Figure 1).

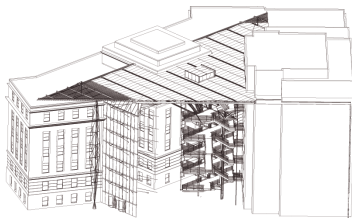


Figure 4: The sloped wall transitions between the vertical wall and skylight. A key feature is the interior and exterior diagonal rods from the top wall kipper truss, which tie and stabilize the wall from the adjacent building.

3.3 Skylight

The skylight is a low ridge and furrow design covering 12,500 square feet in plan area. Generally triangular in plan, the skylight measures approximately 180’ along its north and west edges, and approximately 260’ along its hypotenuse.

The system load path begins with rectangular insulated-laminated glass panels with ceramic frit and low-e coating, measuring 10’-10” by 4’-0”, fully perimeter supported on aluminum frames. The insulated glass panels are tempered with ¼” outer lite, ½” airspace and ¼”-¼” laminated inner lite. The aluminum frames span lengthwise between a series of steel ladder frames composed of channels and pipes (Figure 5). The connection between the aluminum frames and steel ladder frames is achieved with a paddle arm and pin connection. The

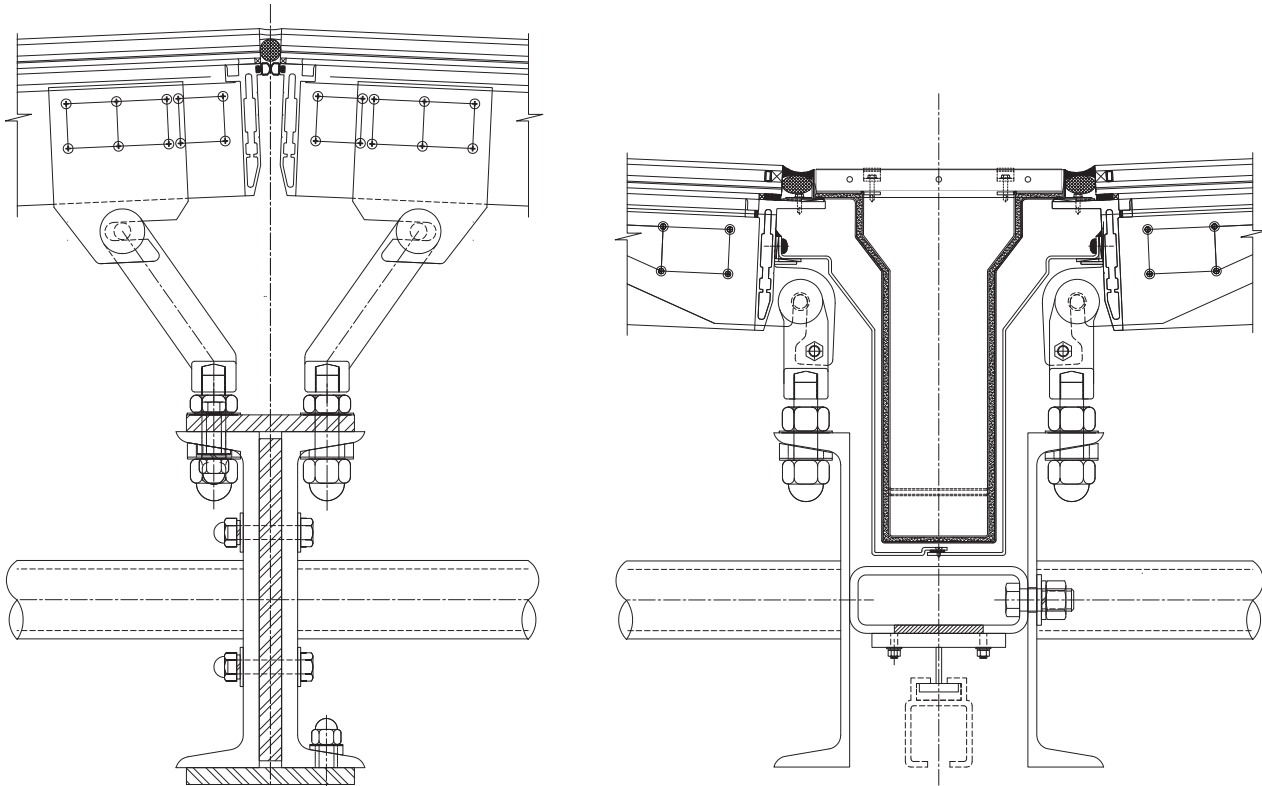


Figure 5: Skylight ladder frame at high-point ridge (left) and low-point valley with integral gutter (right).

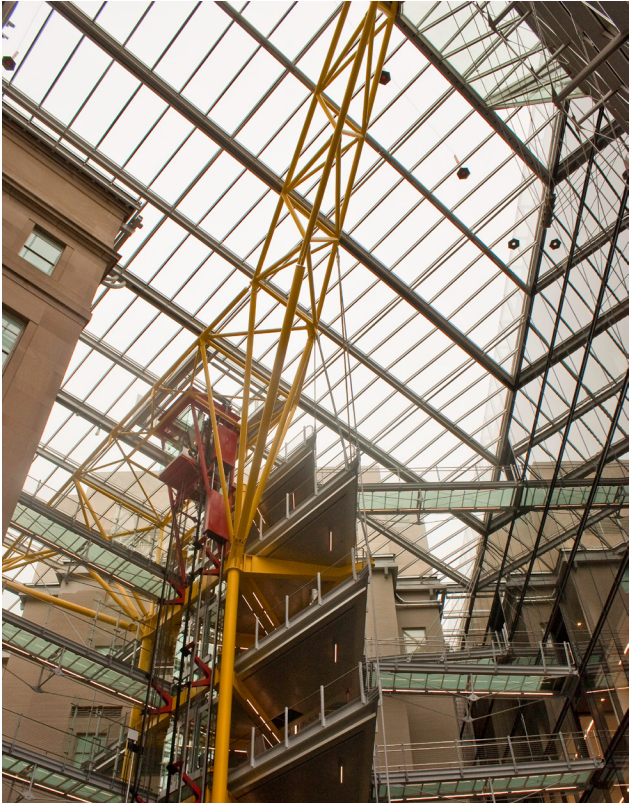


Figure 6: The skylight framing is supported by perimeter building structure and the dramatic yellow “tree” truss which houses central circulation.

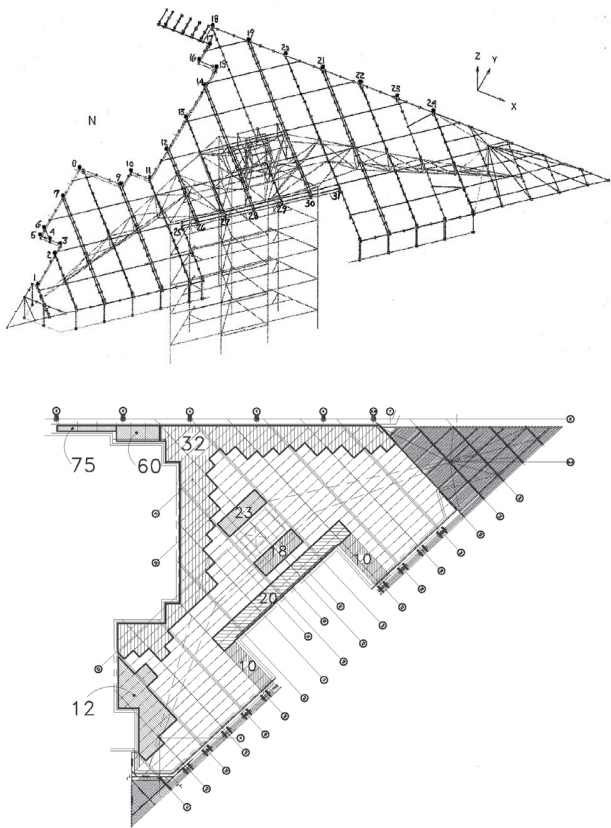


Figure 7: Snow drift loading diagram (bottom) and 3D structural analysis model (top).

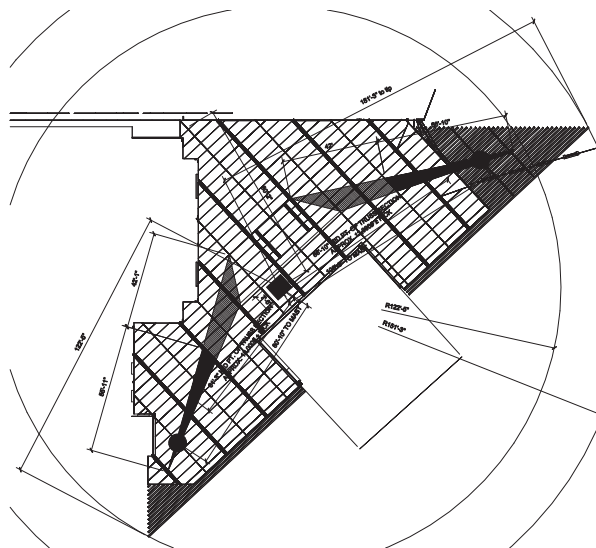


Figure 8. Drawing from crane placement and reach logistical studies.

4 ENGINEERING

4.1 Movement

The skylight, sloped wall, entrance wall and clerestory make up the composite atrium. The glass enclosure actually ties together three separate buildings of dissimilar construction and built during different time periods when building practices and code requirements varied. The result is considerably different behavior between them with respect to movement induced by various loading conditions. Of course, even identical buildings will not move in phase when subject to identical loading conditions. The engineering team built a 3-D digital model of the glass enclosure and surrounding buildings as a tool for studying the relative building movement. The intent was to develop a design for the roof and wall that could fully accommodate these movements with an efficient and minimal structure. Drift conditions are accommodated by providing suitable movement joints between the skylight and the adjacent building structures. At the skylight level, the new building can move up to 2" in any horizontal direction relative to the existing buildings.

4.2 Loading

The critical loading condition of the skylight system was often the result of snow loading. The shallow pitch of the skylight glazing and the irregular geometries of the adjacent structures generated high snow drift design loads (Figure 7).

4.3 Modeling

A computerized analytical model created in the software program SpaceGASS represents the structural elements arranged according to the configuration illustrated on the project drawings (Figure 7). The section properties, material properties, deformation characteristics, and connectivity of the members are considered. The previously introduced design loads are applied, after which, matrix analysis distributes the loads and establishes the response behavior of the structural system.

5 INSTALLATION

Key to the success of the complex installation of the glass enclosure was a custom structural system for the glass wall and skylight that anticipated the requirements for installation in their respective design. The skylight roof system, for example, was prefabricated in fully glazed subassemblies off-site. The supporting structure was also prefabricated and shipped to the site as assembled units. The skylight structural system was designed with a split-beam structural element running in the primary spanning direction. Ladder frames were assembled under factory-controlled conditions into 12-foot wide subassemblies up to 48 feet in length. The finished sections were stacked on flatbed semi-trailers and shipped to the site on a just-in-time basis to minimize site inventory and storage space. The sections were lifted from the trailer by an overhead crane and set directly into position, secured by a simple bolted connection. Crane setting positions were carefully mapped and their availability coordinated with the other trades (Figure 8).

Factory prefabrication concentrated assembly work in the factory, enhancing product quality and minimizing site labor. Detailed installation planning accelerated assembly and installation work, and minimized disruption to this challenging building site.

6 CONCLUSIONS

This project transformed an existing site including two older buildings into a focused office community, with the addition of a new glass-clad mid-rise building and connecting transparent atrium. The development brings a contemporary modernist aesthetic to the traditional architecture of the nation's Capitol, nicely integrating public and private office space in a manner to encourage meaningful social interaction. Design was used as a means to satisfy a challenging building program including advanced facade technology, a constrained building site, an aggressive construction schedule, and the need to minimize

disruption to existing office space, which remained operational throughout construction. Offsite prefabrication was used as a predominant strategy to satisfy the program requirements, and the structure and cladding systems were designed to provide for ease of factory fabrication and assembly, and to facilitate rapid site installation, all without compromise to the minimalist aesthetic of the atrium structure.

ACKNOWLEDGMENTS

The project was completed with collaboration between many firms, individuals, consultants and contractors. Key project team members include; The JBG Companies (owner), Rogers Stirk Harbour + Partners with HKS (architect), Expedition Engineering (structural engineer), TOLK Services (mechanical engineer), MCLA (lighting consultant), Clark Construction Group (general contractor), CDC (glazing consultant), Enclos Corp with Advanced Structures Inc. (specialty glazing design-builder).