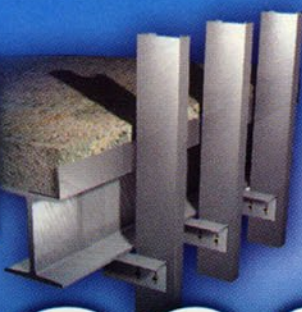


Structural Engineer

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▲ The Pittsburgh Civic Center
— an engineering triumph

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Project Spotlight

50 Engineering exposed: **The Pittsburgh Civic Center**

By Robin Wendler, S.E., and
Deirdre Van Olden

Engineering exposed

By Robin Wendler, S.E., and
Deirdre Van Olden

The Pittsburg Civic Center

(PITTSBURG, CALIF.)



In most buildings, the structural system is the silent partner. It is expected to support the architectural design invisibly but not be visible. At the Pittsburg Civic Center (Pittsburg, CA), ZFA Structural Engineers saw their structural system turned into the essence of the

buildings' architectural vision. The structure is exposed inside and out, presenting unique design challenges that created an expanded role for the project's structural engineer.

Removing cladding and exposing structure is not unusual for large-scale buildings such as athletic facilities and industrial facilities, but it

is rarely seen in office buildings that people continuously inhabit during business hours.

Completed in November 1999 at a cost of \$19 million, the main building houses Pittsburg City Hall, administrative offices, and a police facility. The 70,000-square-foot civic center sits on 23 acres and boasts a mag-

nificent view of nearby Mount Diablo.

The three-story building forms a gentle curve (with a plan radius of about 300 feet and an arc of over 90 degrees) in a semicircular shape around the center lobby, with glass exposing every structural and mechanical element. Manufactured steel joists span radially at

eight-foot on center, supported by steel girder trusses. Each floor steps back from the inside curve of the floor below and aligns on the outside curve, with the stepped areas creating light wells and exterior roof decks and walkways. The central portion of the structure is open from the ground floor up, and has stepping

glass roofs and walls leading from the one-story entry height to the 56-foot-high ridge. The center lobby is the focal point of the building, with a bright red, roller coaster, free-form staircase spiraling up from a marble rotunda.

Full height walls are almost non-existent, so there is nothing to interrupt the view of the



Steel “branches” extend from the central pipe (or trunk) to support the stairs.

joists and girders curving down the length of the building. The longitudinal walls are entirely glass (placed on the inside of the structural steel framework) making the building transparent.

Structure as expression

From the earliest conceptual drawings, structure played an important role in the design of the building. The architect, Fani Hansen (Hansen Associates Architects and Planners, Tiburon, Calif.), envisioned a steel-framed structure that would reflect Pittsburgh's history as a major steel-manufacturing city. She also designed the semi-circular plan and overall shape — adding a humanizing softness to the building and interest to the structural form.

Creating the curved form and intricate

cross-section of stepping floors, light wells, and clerestories required an unusually close collaboration between the architect and engineer. The curve was broken into repeated orthogonal segments and framed with structural steel



The third-floor council chamber with gable manufactured joists and continuous window walls.

joists and girders. Symmetry of the plan was an objective for both aesthetic and economic reasons. The plan is organized around a center, glass-roofed lobby, with symmetric wings on each side. Braced frames are located around the three-story portion of each wing, with additional frames at the one- and two-story perimeters. Horizontal bracing is utilized at clerestory areas to provide continuity for lateral loads.

Steel trusses are the dominant structural and architectural elements of the building — they are light and graceful as well as efficient.

From the earliest conceptual drawings, structure played an important role in the design of the building.

The geometry of the tube steel girder trusses mimics that of the open web steel joists, with the interior structure resembling a space truss as girders and joists intersect. Extensive use of bridging and bracing elements further highlights the truss form. The lateral load-resisting braced frames are arranged as inverted chevrons to blend smoothly with the girder trusses. The trusses also aid the architect's visualization of a light, open interior. No heavy girders block the exterior windows or obstruct the flow of space along the length of the building.

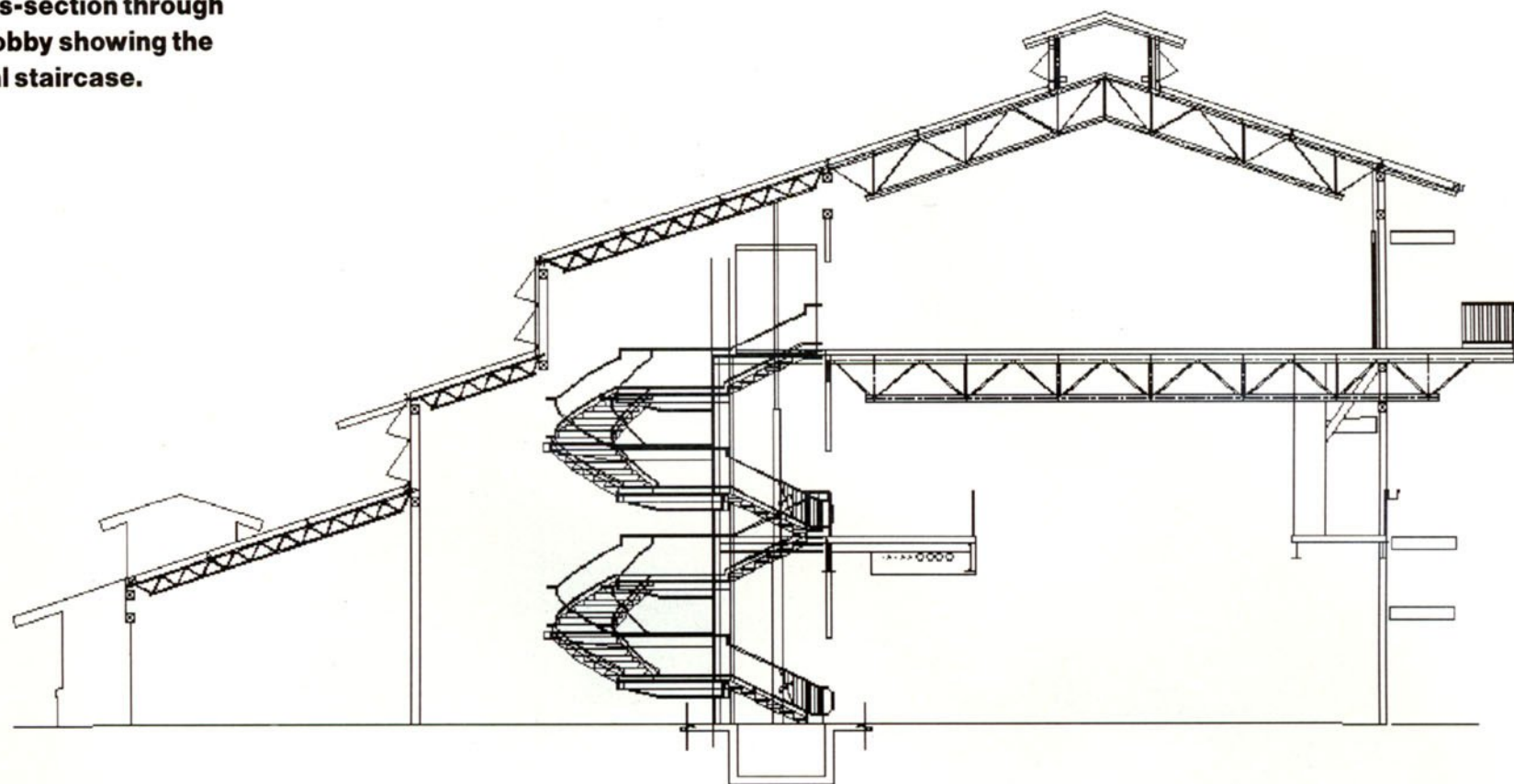
Careful collaboration

Constructing this building required uncommon planning and coordination by all design professionals. In most projects, design development for structural engineers involves



The Civic Center on opening day. The top chords of joists extend to create cantilevered exterior decks.

Cross-section through the lobby showing the spiral staircase.



choosing a structural system and verifying that the structure will fit within the wall, roof, and floor dimensions provided, while at the same time not interfering with architectural, mechanical, or electrical elements. Exposing the structure inside and out created several unique challenges that had to be overcome to allow the structural elements to exist with the other building systems.

The joist manufacturer was involved in early design meetings to discuss configurations, dimensions, member sizes, and finishes. Since the mechanical ducts were to be routed through the joists, it was important to specify their depths and panel points. Uniform joist depths and regular, aligning panel points were selected for each floor, even when varying dimensions would have been more economical. And, the double-angle chord member sizes had to be coordinated with light fixtures and partition support details.

Another example of design development collaboration was in the selection of the metal

decking for floors and roofs. The decking had to meet structural diaphragm requirements and acoustical requirements, as well as to provide space for electrical raceways, and have a

clean, pleasing appearance from below. After the design team determined the specific requirements, a deck was selected with a topping slab for the electrical raceways, acoustic



Gable manufactured joists support glass panels and clerestory.



The exposed mechanical ducts and steel joists result in a light, airy interior office space.

perforations, and bating as required. Lightweight concrete was utilized to reduce the seismic mass of the building. The same metal decking could be used at the sloped roof areas, providing a uniform finish surface.

Piece by piece

The architect's vision of a completely exposed structure guided the design of individual details, as well as the overall building. The intense collaboration between the architect and structural engineer continued through

the preparation of construction documents. In a building where the architectural design relies on the steel elements for its expression, these elements had to be coordinated carefully in order to be aesthetically pleasing as well as efficient. For example, the welded seat connections for the girder trusses were designed to look like corbels, with no

exposed bolts. The corbel design accommodates the 3.2-degree skew at each column and also allows the girders to be dropped onto the

columns and field-welded into place. It also expresses architecturally the support mechanism for the trusses.

Regularity in the member sizes and connections was especially crucial to ensuring that the exposed structure blended and fitted with architectural elements such as windows, rain-water leaders, and sunshades. This was accomplished by electronically overlaying CAD drawings of structural and architectural details and sections. One example of the necessity for regularity is found on the exterior. Because the steel is exposed, the glazing had to fit inside the girder trusses and the first diagonal of the steel joists. Panel points of girder trusses were aligned with window mullions to provide visual continuity between the floors.

Expanding the role of the engineer

To make an office environment function without traditional ceilings and walls required creative structural solutions for design issues rarely involving structural engineers. For example, because of the absence of a wall system, traditional methods of weatherproofing and glazing attachments could not be used. To attach the windows, a continuous steel angle was welded to the inside face of the top chord

Vision of steel

The dramatic image of the civic center was based on Pittsburgh's history as the center of a major steel-manufacturing region since 1910. The U.S. Steel Columbia-Geneva plant (built circa 1926) was the model for the structure. Architect Fani Hansen (Hansen & Associates, Tiburon, Calif.) wanted to tie the building to the center's roots, making a place with which the community could identify. The building's structural steel elements were manufactured just a few miles from the site at Concord Iron Works. The vaulted main roof over the third floor was designed to reflect the local steel mill architecture, rising 25 feet to the ridge, with steel gable trusses spanning 43 feet and a continuous clerestory over the ridge.

"The main lobby is conceived as a cathedral-like space, inspired by Pittsburgh's steel mill architecture," said Hansen. "Landscape and water features evoke the fishing heritage, and paving patterns incorporate ethnic art motifs," she said. "The steel structure, visible from the exterior and interior, includes exhibit space and murals, elements of local history with color, and artwork to identify Pittsburgh's diversity."

Regularity in the member sizes and connections was especially crucial...

of the girder truss at the roof. At the second floor, where the manufactured joists cantilever through the window wall, a continuous steel tube was welded to the bottom chord of the joist (aligning with the joist panel point) to support the glazing above and below. A vertical tube section was seal-welded at each joist since the glazing could not continue through the joist, but stopped at each side. To seal the building exterior, the steel channel between the underside of the metal decking and the top

Project Breakdown

● **Construction Cost** **\$19,600,000**

● **Total Area** **70,000 sf**

● **Quantity of Steel**

Structural Steel, 5176 tons;
Steel joists, 149.5 tons

● **Savings**

Close collaboration between architect, engineer, and design team members reduced cost and allowed 26 percent of the money to remain in Pittsburgh.

● **Owner**

City of Pittsburgh.

● **Architect**

Fani Danadjieva Hansen, Hansen Associates Architects (Tiburon, Calif.).

● **Structural Engineer**

Robin Wendler, ZFA Structural Engineers (Santa Rosa, Calif.).

● **Contractor**

Project manager, Dan Warren.
Lathrop Construction (Benicia, Calif.).

● **Steel Detailer**

David Mays, Universal Detailing Co. (Fremont, Calif.).

● **Steel Erector/Fabricator**

Concord Iron Works (Pittsburg, Calif.).

Robin Wendler, S.E., is a structural engineer and managing principal for ZFA Structural Engineers in Santa Rosa, Calif. Wendler specializes in public facilities work and served as the lead structural engineer and project manager for the Pittsburgh Civic Center. She is a member of the American Society of Women Engineers. **Deirdre Van Olden** is the marketing coordinator and Webmaster for ZFA Structural Engineers. She earned her bachelor's in English Literature at Sonoma State University.

of the truss provided both shear transfer and weather closure, with continuous welding sealing the inside space.

To form enclosed offices, steel ceiling framing is suspended one foot from the bottom of the floor joists above and braced to the floor above for lateral support. This also minimized the interruption of the flow of natural light. The plywood ceilings' "lids" are painted with a reflective paint to increase the natural light illumination from the exterior windows at the interior common space. The open office space design formed through the exposed structure not only created an enviable working environment; it produced a savings of about 70 percent of normal lighting expense.

A successful learning curve

The design of the Pittsburgh Civic Center leans heavily on structure for its architectural expression and dramatic image. Careful planning during design development was essential to ensuring that the structure worked with other systems. It was critical that the engineer and architect worked closely on every detail to ensure that the building would perform as intended while retaining the architect's



An inverted chevron braced frame is blended into a typical girder truss.

aesthetic vision. While this level of scrutiny can be difficult, the success of the project was dependent upon completing the design process thoroughly and accurately.

This project exerted greater demands than normal on the structural engineering team, yet the rewards were greater as well. Seeing the beauty of the structural elements expressed — and sharing it with a community — is a rare pleasure for a structural engineer. ■