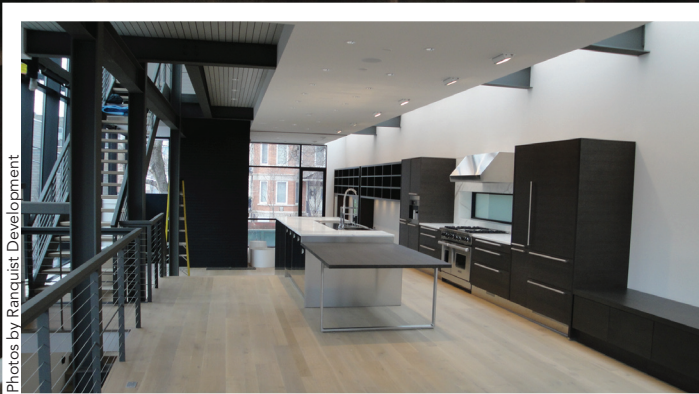




A Steel Home on Wood

BY BRIAN COURT, AIA AND JEFF PRIBYL, P.E., S.E.



Photos by Ranquist Development

This page: Three views of the main floor with the main steel moment frame running the length of the house.

BOB RANQUIST HAS BEEN BUILDING ultra modern single family homes and multi-unit condominiums in Chicago for the last decade. The client for this new residence in the city's Bucktown neighborhood had lived in a Ranquist house for many years. Once he married and decided to have a family the need arose for a larger house. He went back to Ranquist for a new house. Ranquist brought on Miller | Hull, Seattle, as the design architect and Osterhaus McCarthy, Chicago, as the architect of record. The team had just finished a 10-unit condominium in the same neighborhood.

Miller | Hull conceived of the house as a series of boxes containing the private family spaces (bedrooms and baths) on the upper level floating over an open, free-flowing main level with the shared family spaces. The main floor is a series of stepped planes, lifted up above a partial basement, that incrementally steps up and bridges over the rear yard to a roof deck above the garage. A daylight basement contains guest rooms, theater, storage spaces, mechanical/electrical and play spaces for the children.

Structural System

The long narrow site measures 33 ft wide and 125 ft long and the desire for an open plan did not allow for transverse shear walls. Long spans and large openings and cantilevered volumes would have exceeded the capabilities of a wood frame. A hybrid system of

steel primary members and wood secondary members proved to be the ideal design solution. Ranquist's previous residential work had been almost exclusively based on a structural system of masonry block and wood frame with open web trusses and initially there was skepticism about the added cost of the steel frame for a project of this size. Fortunately the steel estimates came in on budget and we were off and running.

The structural approach to the house was simply to use materials in appropriate ways—concrete and masonry where the building touches the earth, steel for height and span, and light wood frame everywhere else. A central spine of steel columns runs the length of the house supporting the upper floor bedrooms. The second floor is held back 4 ft along the north side of the building allowing a continuous skylight the length of the house that brings an abundant amount of natural light to the main floor spaces.

Structural Expression

One of the primary design philosophies at Miller | Hull has long been to express the structure of building to help define the space and bring a level of richness and articulation to a building. Using the essential elements of a building to bring character and interest frees the architect of the obligation to apply expensive finishes and decoration. Fortunately, one the homeowners previously had lived

Conceived with a spine of steel,
this urban residence offers open
spaces and lots of light.



The Miller\Hull Partnership

A steel spine enabled the creation of this spacious and open urban residence on a long, narrow site.

in converted loft spaces in New York and had developed an affinity for the industrial feel and scale of these spaces.

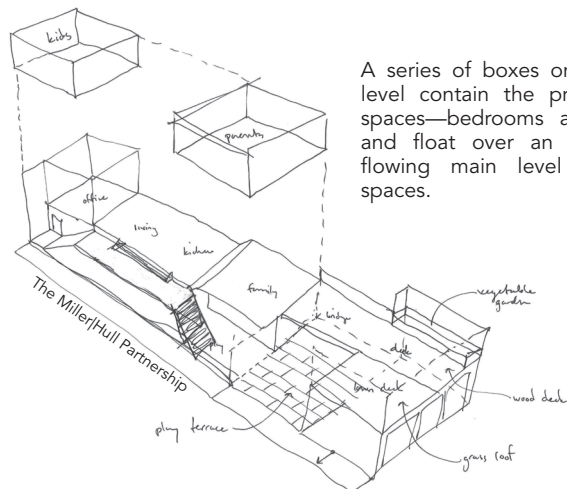
The design of this home sought to express as much of the steel and connections as possible. A good example of this is location of the splice plates on the three-story steel frame that supports the roof monitor. Instead of hiding them or locating them in an out-of-sight location, they instead were placed in a visually prominent location, right at the second story bridge.

To minimize thermal transfer issues the steel columns are inset from exterior walls and beams cantilever as required. Not only does this design detail improve the building performance, it also brings a heightened awareness of structure.

Load Resistance

The lateral load resisting system of the building consists of steel moment frames, cantilevered columns, concrete masonry unit (CMU) shear walls and plywood shear walls. Three steel moment frames consisting of W8 columns and W14 beams span the short direction of the building to provide stability up to the second floor level. A single story CMU wall provides additional stiffness at the front of the house.

Because the building steps back approximately 4 ft along the north wall at the second floor, the steel frames could not continue



A series of boxes on the upper level contain the private family spaces—bedrooms and baths—and float over an open, free-flowing main level of shared spaces.

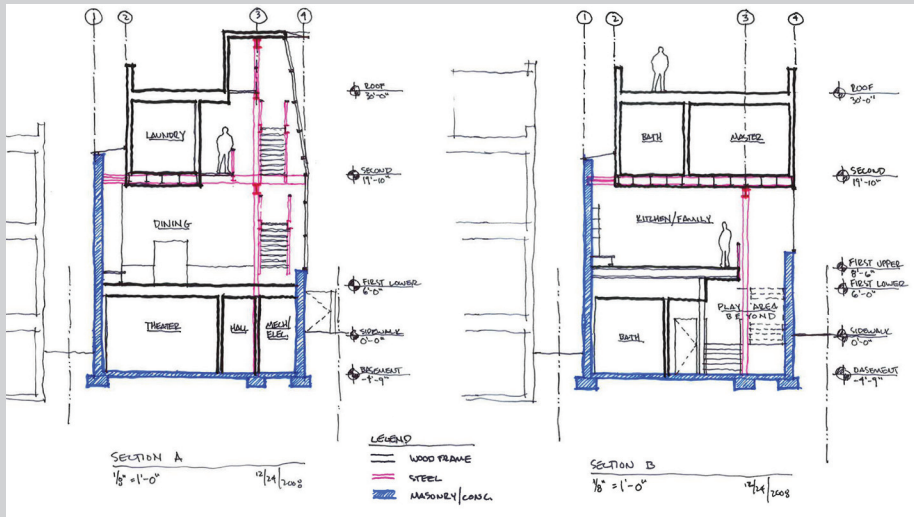
Brian Court, AIA, LEED AP, is an associate in the Miller\Hull Partnership, where he has practiced for the past 10 years.

Jeff Pribyl, S.E., P.E., is co-founder of Chicago-based SP Engineers, Ltd.



Balancing Expression and Necessity

Comments from the architect of record, Scott Osterhaus



No visual manifestation of the shear structure detracts from the expression of the floating and cantilevered floor above. The structural functions are split depending on the column line location to achieve a distinct role in the stability of the overall building.

up to the roof level. Interior and exterior plywood shear walls from the second floor to the roof provide bracing for the roof level. Cantilevered W8 columns, which are braced by the roof level diaphragm, extend up to stabilize the penthouse.

The lateral system in the long direction of the building consists of a similar combination framework. At the second floor level the continuous skylight isolates the floor diaphragm from the exterior CMU shear wall. Because the loads were relatively small, the lateral force could be transferred to the wall through weak-axis bending of the W14 floor beams.

A NanaWall door system at the back of the house made it important to keep lateral deflection in the short direction to a minimum in order to ensure its proper operation. Architecturally the columns were limited to W8 sizes and the beams to W14s. Using moment connections at the base of the columns limits the deflection to $L/600$ at the Nana wall location. Grade beams span the short direction of the building at the frame locations to resist the column moments and overturning of the frames.

The gravity system consists of open web wood floor trusses supported on steel beams, load-bearing wood stud walls and exterior CMU walls. By incorporating steel as the primary support structure it was possible to cantilever the framing, remove columns and transfer column loads which would not have been possible with wood alone.

At the top of the structure the penthouse

skylight roof is supported with steel beams cantilevered from the W8 columns. The roof level is designed to support a 100 psf live load in addition to 50 psf for the possible addition of a green roof. The roof trusses are supported by steel beams and load-bearing wood stud walls. W14x43 beams cantilever out 8 ft at the back of the structure to support the roof framing in order to eliminate corner columns.

Below the second floor is a continuous ribbon of windows along the south wall, the north wall is stepped back for the continuous skylight, and the east and west walls are stepped back below. A ring of steel around the perimeter of the building is used to support the floor framing and walls above. Similar to the roof, beams are cantilevered at the back of the building to eliminate corner columns.

The columns along the south wall are shifted 3 in. from the first to second floors in order to keep the columns inside the windows. This created constructability problems because the perimeter steel had to be continuous to create the cantilever at the back of the building. A 1½-in. bearing plate was used at the top of the column to support the eccentric load from above; a stiffener could not be added below the plate because it would interfere with the window frames.

The typical beam-to-beam connections are double-angle field-bolted connections. However, to keep the exposed beam-to-column moment connections clean, field welded connections were used. Providing

Different cross sections through the building frame reveal how the structural necessities of the architectural expression are resolved independently at different column lines.

The north-south beams adjacent to the open stair are offset from the column itself and pass over the east-west column line beam to efficiently express and structure the cantilever that provides support for the glass curtain wall. At other cross sections, the north-south beams are in line with the column, connected to it and to a hidden partner in the masonry wall with a moment connection that provides the lateral support required. While the cantilevered beam connections are exposed, the moment connections are hidden in the ceiling.

forces for each moment connection to the steel fabricator helped minimize connection sizes.

MSC

Architect

The Miller | Hull Partnership, Seattle

Architect of Record

Osterhaus McCarthy, Chicago

Structural Engineer

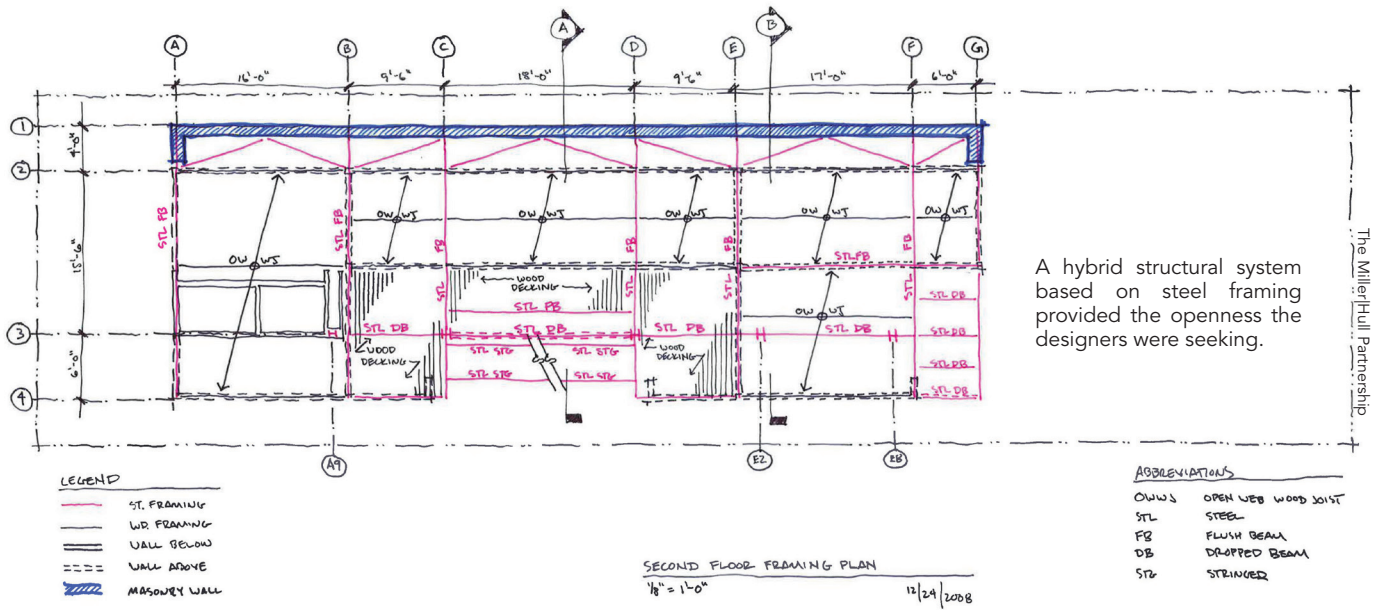
SP Engineers, Ltd., Chicago (AISC Member)

Steel Detailer and Fabricator

Crest Metal Craft, Inc., Chicago (AISC Member)

General Contractor

Ranquist Development, Chicago



Photos this page by Ranquist Development



Above: With almost the entire steel frame in place, installation of the other building elements could proceed quickly.

Right: The column splices on the second floor level occupy a place of visual prominence, further expressing the structure's significant role within the home.