WoodWorks

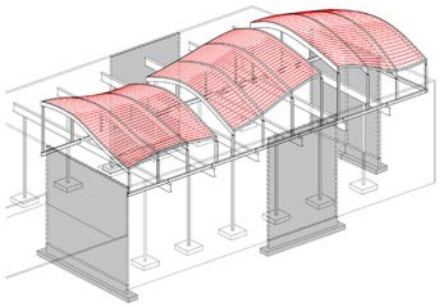
CaseStudy

Changing the Shape of Wood Construction

3555 Hayden takes warehouse from ordinary to extraordinary

At first glance, the project assignment may have looked ordinary—almost dull. Their job was to add a 6,000-square-foot rooftop addition onto a 1950s-era brick and concrete (CMU) warehouse in Southern California. But designs from the team at Eric Owen Moss Architects are anything but ordinary, so they explored the possibilities and took wood to the edge as they used curved and beveled glulam beams to form the innovative roof.

And the results? Extraordinary.



Creative Addition to an Existing Structure

According to Dolan Daggett, project director for Eric Owen Moss Architects, the brick warehouse at 3555 Hayden Avenue in Culver City had already undergone one renovation in 1997, when a CMU second-story post-production studio and sound stage was added above the original brick box.

Structurlam Products used a five-axis CNC machine to arch and bevel the huge glulam beams.

"At that time, we knew we would come back someday and add a third floor, so we added columns and perimeter beams to the existing studio structure," Daggett said.

In 2004, Eric Owen Moss Architects began design work to add a third floor addition on top of the sound studio, to give the building owner an open office space. The architectural team, well-known for their innovative use of form and space, designed a complex, undulating roofline with its structure exposed to the interior. The design won media attention as well as a 2008 Research and Technology Honor Award from the California Council of the American Institute of Architects and the 2010 Commercial Wood Design Award from WoodWorks California.

Their creative approach also allowed them to overcome one of the city's zoning constraints.

"Culver City has a height limit of 43 feet, but allows architectural features up to 56 feet 6 inches over a maximum 15 percent of the total roof area," explained Daggett. "So, we varied the rooflines of the third floor addition—not to gain additional square footage, but to average the 15 percent provision across a continuously undulating roof surface, to create a more interesting structure that still would meet code."

Architects used the redundant steel structure, which had been inserted along the building's perimeter to accommodate future vertical expansion, to support the steel and wood columns that extend from the perimeter frame. The wood roof structure, exposed to the interior, features arched and beveled glulam beams with custom-cut wood rafters.

Wood – the Shape of Things to Come

The use of wood was essential to the team's ability to create the undulating roofline design for 3555 Hayden.

"The most important thing for us was the shape of the roof," said Daggett. "From a design perspective, we wanted the roof to do more for this building. In order to exaggerate the form and construct a more exuberant design element, we needed a pliable, shapeable structural material. After consideration, we determined wood was the right product to achieve our goal."

He also emphasized that wood allowed them to express the structure to the interior. "We knew we could expose wood elements, which are a major part of the visual reading from inside the space. We did not want to bury the structure. We also needed wood to give us the structural capacities that were required."

The project's engineer agreed, both from a structural and an aesthetic point of view. "Wood has the unique ability to shape the building, to follow the profile," said Lawrence Ho, principal of Englekirk Partners Consulting Structural Engineers, Inc. "I cannot think of another material that would have worked as well. We could have tried concrete, but it would have been one cold space, not to mention outrageously expensive. We could have shaped steel, but it would not have had the warm look and feeling of the wood. And, steel would have cost more. Wood offered the best combination—to achieve the warm aesthetic that Eric Owen Moss Architects wanted to create ***and*** to get the shape they were looking for."

Both Ho and Daggett agreed that wood was both light and easy to frame over the existing structure as well as structurally efficient for the spans. "To form that shape out of any other building material would have been much more expensive," summed Daggett. "Plus, it gave us a product with the ability to be formed in a cost-effective manner. That's the real logic of why we used wood."

Compound Slopes Increased Complexity

Architects formed the complex roof structure with 22 glulam beams, ranging in length from 16 to 52 feet. The manufacturer finished the Douglas fir beams, sized from 5-1/8 to 6-3/4 inches wide and 9 to 30 inches deep, to an architectural appearance. The contractor installed the beams at 12-foot centers, with 2x rafters at 16-inch centers spanning between the beams.

The arched beams were manufactured with specific curvatures, then a computer numerical controlled (CNC) machine cut a continuous bevel on the beam's top edge to form the necessary compound slopes.

"We beveled the tops of the beams to create a seamless, flowing roofline," said Daggett. "Since the beams and rafters are exposed on the inside, only the tops of the beams were beveled, so that the undersides maintained their original shape.

Leveraged Technology Leads to CNC Magic

Structurlam Products in Penticton, BC was easily able to accommodate the complex geometries needed for 3555 Hayden's glulam beams because they have a five-axis CNC machine capable of modifying large, arched glulam members. They anchored the beams to their shop floor, and then moved the CNC machine, manufactured by Le Créneau Industriel, over the glulam beam using a gantry crane.

Leveraged technology lies at the heart of the operation. Architects at Eric Owen Moss built a 3-D model for the 3555 Hayden building, and then worked to make better use of the data in order to move more seamlessly from computer-aided design to fabrication.

"The architects at Eric Owen Moss transferred their 3-D models as Rhino files to Structurlam," said Kris Spickler with Structurlam Products. "We fed them into our CADWorks software to confirm the dimensions, and then sent the data to the CNC machine. The approach takes more up-front work from the architect and engineer, but results in almost limitless possibilities in terms of the finished beams."

Each CNC-fabricated rafter was custom cut and notched for its specific location in the roof structure. No two were alike.

It was a complex but achievable job, added Spickler, who said the glulam beams arrived in Culver City from Canada just 12 weeks after Eric Owen Moss Architects submitted their 3-D Rhino files. "In 2007, this was one of our more complicated assignments. But it didn't stretch what we could do with the CNC machine and we've learned a lot since then. Looking back, this project was relatively simple compared with what we can do now."

Wood Components Delivered as a 'Kit of Parts'

Spectrum Oak, the architectural millwork company located in Orange, CA that supplied the custom cut rafters, also used the 3-D design data. They machined the 2x10, 2x12 and 2x14

rafters with a smaller CNC mill to create a curved top edge that could conform to the underside of the roof surface. Each rafter was then notched at the ends in order to receive a standard metal hanger. Because no two were alike, all rafters were precisely machined and coded for their particular location in the roof structure.

"The roof structure went together like a kit of parts, pieced together at the job site," explained Daggett. "All fabrication was done before materials arrived at the job site, and our contractor, Samitaur Constructs, just had to put it together."

Once the beams and rafters were erected, the contractor added two layers of 1/2-inch plywood, which also served as part of the roof diaphragm. "We used two layers because the panels had to be thin enough to flex over the undulating roof lines," said Daggett. "Alignment of the panels was critical; we needed to make sure the seams were smooth, and that they fell on rafter and beam lines for proper nailing."

Because the beams and rafters were left exposed to the interior, 3555 Hayden included a 3-inch cavity with a flexible steel track above the plywood, which created a pocket for insulation. This was then covered with fire-resistant cement board on the exterior. Originally, the roof was clad in field-applied fiberglass. Since then, the contractor has added a continuous elastomeric coating.

The project used 2x6 and 2x8 traditionally-framed stud walls with exterior plywood for shear strength. It also has a 2x12 raised wood floor with plywood decking over the existing wood roof system.

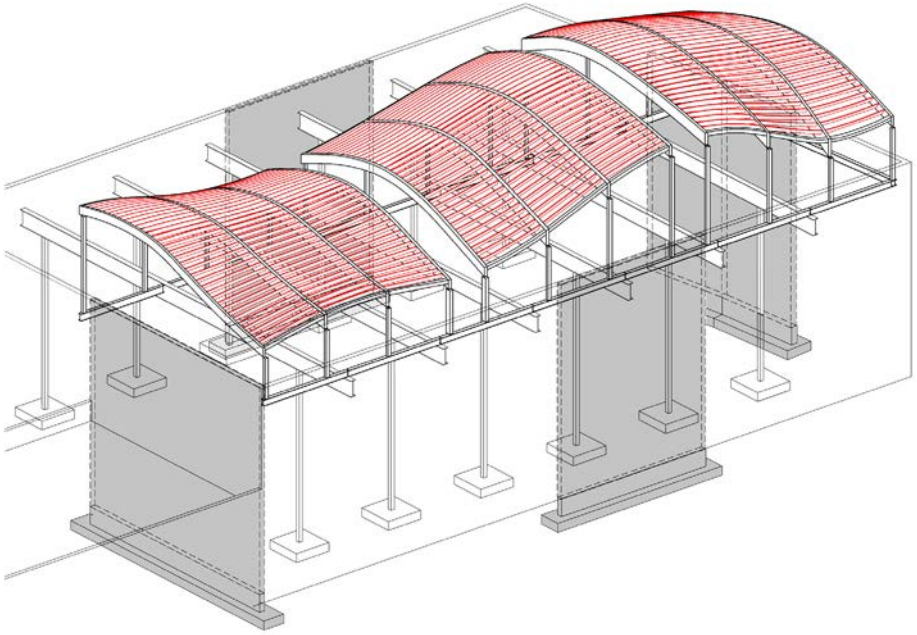
Design and Construction Challenges

Ho said the project included its share of engineering challenges. "Our detailing had to complement what the architects wanted, which was a smooth roofline both inside and out," he said. "Many of the connections that we detailed were different from the standard glulam connection details we're so familiar with. They were tailored for this particular design, so that was the biggest challenge from our perspective."

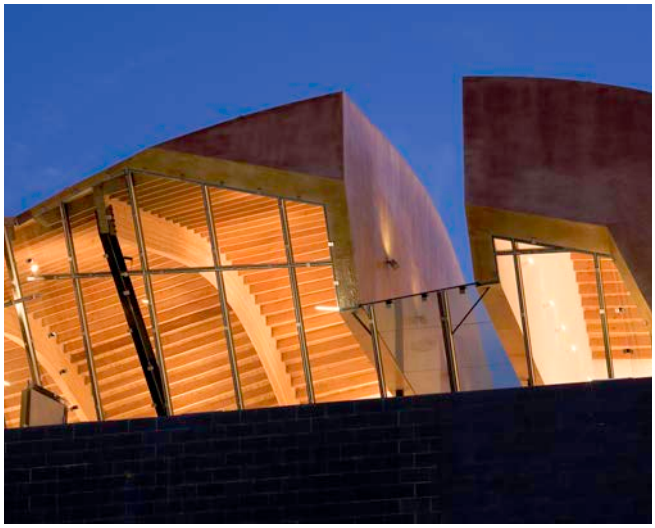
The building was fully sprinklered, but from the sidewall, to keep a clean, uncluttered view of the wood roof structure from inside. They also installed up-lights from the walls for the same reason.

Daggett noted that construction went quite smoothly, due to the detailed design work done ahead of time. "The Samitaur Constructs team hoisted the beams into place with a crane and just connected the pieces. Everything had to be in the right place, though, because we'd already cut the rafters. We needed to hit our field measurements right on, which increased our emphasis on tolerances."

To install the rafters, they constructed a 6-foot-long, two-pronged fork that could be slotted over a rafter and used to twist it into position, to square the rafter on each end to the glulam beam and to assure a perpendicular relationship between the rafter and roof surface.



Eric Owen Moss Architects used Rhino to build a 3-D computer model of the roof components. The same data was used to fabricate the glulam beams and rafters.



Each beam was laminated to a unique curvature and its top surface beveled to create the undulating roofline.

Why Wood

Daggett said Eric Owen Moss never even considered the option to use steel. "We didn't do a cost comparison to compare wood with other framing materials. We just made the decision to use wood early on, and never looked back."

While their decision to use wood was driven by design and structural needs, he adds that wood's advantages in terms of being a more sustainable building material was just "an added benefit. We use a variety of materials in our projects, and our decision to use one material over another is driven by our desire to take advantage of the product's attributes in a particular application," said Daggett. "We made our decision for 3555 Hayden based on what was the best, most economical way to create this design. Wood was the clear answer."

Daggett added that they could have met their design goals with another structural building material, but it would have resulted in a very different building. In addition, he estimates that steel would have been cost prohibitive and would not have resulted in the same aesthetic quality. "We wanted an exposed structure that could be visible from the indoor space, so people could see and understand how the building was made. Wood allowed us to do that, both aesthetically and economically."

Wood offered other benefits in terms of its structural properties. 3555 Hayden was built in compliance with 2001 Title 24, Part 2 of the California Building Code. It was also designed to meet the requirements of a 70 mph design wind speed with exposure B in seismic zone 4.

"There's no question that, being in Southern California, seismic is one of our biggest considerations," added Ho. "As engineers, we briefly compared steel and concrete to wood for 3555 Hayden, just to ask 'what if.' Could we have used steel or concrete, and then clad it with wood to get the same look? I suppose you could argue for that approach. But here in earthquake country, we really want a lightweight structure—the lighter, the better because the seismic demands change proportionately with the structure's weight. A wood-framed building is a lighter structure that just performs better in seismic conditions. I think that's another inherent benefit of using wood in a building like this."

No Reason to Stop Now

Both Daggett and Ho agreed that there is value in taking the time to evaluate the possibilities in solving design challenges using wood, but Daggett emphasized the fact that Eric Owen Moss Architects focuses on using the material that is best suited for the application. "We're interested in exploring material solutions in form and space, so we put a lot of energy and time into that. For this project, our best solution was wood."

Having seen that wood design could be taken to the edge like this has changed his firm's perspectives, Ho said. "Englekirk Partners Consulting Structural Engineers has done a lot of projects with wood, but we had not taken wood to the level that Eric Owen Moss did with 3555 Hayden. They really pushed the envelope with this project in terms of curved and beveled glulams. As structural engineers, it was a welcome challenge for us. And there's no reason for us to stop now."

Spickler added that the commercial construction industry has just scratched the surface of what's possible with wood. "Can we do huge moment connections with wood? Yes. Can we shape beams, make them oval and allow them to form continuous, compound slopes? Yes, of course. Innovative design firms are becoming increasingly aware of wood's potential, and starting to do more creative projects like 3555 Hayden. Architects across North America are really waking up in terms of what they can do with wood."

Eric Owen Moss Architects used a sidewall application for lighting and sprinklers to keep the wood roof/ceiling uncluttered.

Project Overview

Name:	3555 Hayden
Location:	Culver City, CA
Owner:	Samitaur Constructs Frederick and Laurie Samitaur Smith
Architect:	Eric Owen Moss Architects
Structural Engineer:	Englekirk Partners Consulting Structural Engineers, Inc.
General Contractor:	Samitaur Constructs
Glulam Supplier:	Structurlam Products Ltd.
Completed:	2007
Awards:	WoodWorks California 2010 Commercial Wood Design Award, AIACC Achievement Award, 2008

Photography on cover and back by Tom Bonner Photography.
Interior Photos: (l to r) Eric Owen Moss Architects, Eric Owen Moss Architects, Tom Bonner Photography, 3-D computer model: Eric Owen Moss Architects.

WoodWorks is an initiative of the Wood Products Council, which includes all of the major North American wood associations.