Frank Gehry’s buildings are probably the most easily recognizable in the world. Swaddled in curves and unusual shapes, his structures often defy convention. And there’s no more easy a way of describing one of the renowned architect’s buildings than there is constructing one.

That especially applies to his latest venture, the Walt Disney Concert Hall Auditorium being constructed in downtown Los Angeles. When completed next year, the striking stainless steel clad triumph will consist of a series of curving and folding shapes, all different from each other, presenting what some will say looks more like a giant sculpture
Frank Gehry's Walt Disney Concert Hall Auditorium is being constructed in downtown Los Angeles.
than a building. But looks can be deceiving. The 2,265-seat hall, designed by Frank Gehry & Associates in collaboration with renowned Japanese acousticians Yasuhisa Toyota and Minoru Nagata of Nagata Acoustics, is being billed as one of the most acoustically sophisticated concert halls in the world.

AWCI’s Construction Dimensions talked to some of the contractors at the job site about the task of building the unique building. “Scheduling-wise, administrative-wise and building-wise this has been an incredibly challenging project,” explains Robert Klugh, operations manager of Los Angeles-based Martin Bros./Marcowall, Inc. “One of the founders of Martin Bros., Dick Martin, has never seen anything of this magnitude or complication in his many years with the company.”

The company’s contract-worth between $20 million and $25 million-includes framing and interior finishing such as plastering and drywall. From the outset the project has thrown Martin Bros. curveballs. Developing a method for creating a substrate for surfaces that twist and turn in every direction is one example of the challenge the contractor has been up against. Martin Bros. had experience doing tenant improvements using curvature tracks and studs to create curved ceilings and walls, but the company had never done anything as complex or as large as Disney’s concert hall. “A lot of the project is not ruled, meaning that it doesn’t have straight surfaces. Many surfaces have a compound effect, like a dishing or bulging effect,” Klugh explains.

In the first vision of the Disney Concert Hall, Gehry proposed it be made of stone.
Initially, Gehry gave the unusual geometric shapes common names like pillow, moustache, boot, satellite dish and knuckle so the building team could easily identify his references. “It really helped us in meetings and work sessions,” points out David Aguilera, vice president of Martin Bros. Shapes range from ruled surfaces with straight edges to compound ruled surfaces with complex curvilinear geometry. The latter required studs bent, stretch-formed and crimped to form shapes meeting stringent specifications. The team had to conduct independent tests to ensure that each framing member maintained sufficient structural integrity when bent and stretch-formed. Most steel stud framing members are welded, rather than fastened. Many are attached to structural iron and steel members for support.

Had to Go Outside the Box

To achieve precise tolerances for the geometric shapes, Martin Bros. went through a lot of “trial and error,” and got help developing concepts for mock-ups from Gehry, adds Aguilera. The work wouldn’t have been possible with conventional CAD software. As testimony to how exact each wall and ceiling panel had to be, a joint even half an inch off in one place would cause a ripple effect that might defeat the entire construction process.

Martin Bros. retained Rick Smith of Los Angeles-based C-Cubed Virtual Architecture to create the precise complex shapes and forms using a computer program called CATIA (computer-aided three-dimensional interactive application), which was developed for the aerospace industry in the early 1980s. CATIA analogous to AutoCAD, allows the building team to extract data from the computer program and survey it in the field.

In a nutshell here’s how the 3D software works: The process begins with Gehry creating a physical model made of paper and cardboard. A “digitized pencil” is then used to copy the exact shape of the model onto the 3D computer program. Construction details, such as structural steel members and metal panels, are then also input into the computer. The idea is to input everything (obviously excluding items like door knobs and hinges) that will require coordination of the trades on the job site, Klugh explains.

What sets CATIA apart from much of the competitive three-dimensional software on the market is power and capability. “This system has everything to do the whole job,” Smith points out, noting it eliminates the need for any conventional shop drawings. “We can extract a lot of information from the computer that goes directly to the fabricator or to the erection or location it is needed on the job site. We virtually build the building in a three-dimensional world.”
the ceiling, CATIA makes precise calculations that are input into a numerically controlled milling machine to ensure exact cutting.

To create the unusual shapes, the first step is to find the isoparms, a geometric term that refers to the straight line within any shape. CATIA is made for this purpose. The software program separated each of the many unusual surfaces in the building and put each one on a computer monitor so it could be analyzed from every possible angle.

**Maybe It Is Rocket Science**

The 3D system has become a household name in the aerospace industry where it was first used in 1982. Smith worked on the design of the Space Shuttle, the C-130 cargo jet and other important aerospace projects before he hooked up with Gehry to design an eight-story fish-shaped sculpture for the 1992 Olympics in Barcelona, Spain. He was also involved in the first vision of the Disney Concert Hall, which was proposed to be made of stone. Gehry eventually decided to go with a stainless steel-clad metal frame structure in part because of concerns that the stone structure could be extensively damaged in an earthquake.

While integrating as many facets of the construction process as
possible onto CATIA ensures a smooth operation, not all con-
tractors were sold on using the 3D program when first intro-
duced to it. “It was a challenge convincing all the contractors
that the more we could coordinate within one three-dimen-
sional computer model, the better the job would run. Obvi-
ously it is a very free-form shaped building, and a computer
would be needed to control construction,” Smith says.

One of the most challenging aspects of the contract for Martin
Bros. was educating the tradespeople to adapting it as a tool for
their work. “You have craftsman used to performing work one
way. Now they have to rely on data from a computer, rather than
their instincts, to build things,” says Klugh, noting that CATIA
allows for a fast-paced schedule because it eliminates Requests
for Information. “For us to go back to determine our own
dimensioning, our substrates or determine anything else would
have obviously involved an extensive RFI process,” he says.

A complex aspect of the project was the coordination of the
 trades involved in the design, construction and installation of
the acoustical ceiling in the orchestra area of the hall. The ceiling
is a complex animal comprised of primary and secondary
frame structures, wood paneling, structural steel secured to the

Shapes range from ruled surfaces with
straight edges to compound ruled sur-
faces with complex curvilinear geometry.
The company also retained several fabricators for steel framing members. One of them was Radius Track, a firm that had developed a method for crimping studs to meet exacting job specifications like this one.

Plaster work will present a challenge because the surface must be knife-edge smooth to maximize acoustic quality. “You have to minimize undulations in the walls,” Klugh says. A sound acoustician from Japan will inspect the entire surface for voids, waves and imperfections.

**Ahead of the Pack**

When the project came up for tender a few years ago Martin Bros. had the inside track, having worked on the original project back in 1989, which was canceled due to financing difficulties. The contractor’s experience doing mock-ups for the complex back then, plus its work on a performing arts center in Orange County helped it land the contact. “I think the stringent specs and not knowing how exactly the project was going to be put together deterred a lot of our competitors from bidding,” Aguilera adds.

The work of Martin Bros. will be substantially complete next month, with the hall itself to open in 2003. As for future work with Gehry, Martin Bros.’s Aguilera says the company will keep close tabs on Gehry projects world-wide. And why not? “We feel we are pioneers, changing the way construction is going to be from here on out. There’s a lot of interest from a lot of contractors and architects that want to see what is going on here.”

Over at C-Cubed Virtual Architecture, Smith adds that CATIA is not limited to complex building designs like those coming out of Gehry’s office. Even conventional straight-walled buildings could benefit from the 3D technology.

“You can do a better job of coordinating the trades using it than you can using paper drawings,” Smith says. “Working with 2D drawings and trying to have your mind connect the details of one drawing to another is not easy. With this system you see exactly what you are going to build in 3D. You have to do a little more work on the design end, but it makes life easier in the field. Ultimately, I think this will revolutionize the method of construction in the world.”

**About the Author**

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