DASSAULT SYSTEMES

CATIA

SHoP Architects & SHoP Construction

Architecture, Engineering and Construction Case Study

shop + SC

Challenge
Design and help deliver a new façade for the Barclays Center basketball arena in Brooklyn that is both architecturally unique and efficient to build.

Solution
SHoP Architects and SHoP Construction (SC), collectively known as SHoP, chose Dassault Systèmes' **3D**EXPERIENCE application for virtual product design, CATIA, to design and develop an integrated 3D model of the Barclays Center arena which would provide detailed data for off-site fabrication and on-site construction coordination.

Benefits
The 3D model developed in Dassault Systèmes' CATIA application simplified and accelerated fabrication of approximately 12,000 unique steel panels, optimized material use to reduce material costs by 25%, and provided the data to track each component to facilitate efficient on-site installation.

Delivering unique architecture and efficient construction with 3DEXPERIENCE

Barclays Center arena, the new home to the Brooklyn Nets of the National Basketball Association, has earned more than its share of praise as an iconic architectural landmark.

The New York Times wrote, "SHoP has spared Brooklyn another retro stadium. The architects have created something tougher, more textured and compelling, an anti-Manhattan monument, not clad in glass or titanium but muscular and progressive, like its borough."

Much of the building's character comes from its façade, a latticework system composed of 12,000 pre-weathered steel panels — each of them unique in size and shape. The panels cover 85 percent of the Barclays Center's exterior surface.

Remarkably, the façade was developed late in the design process, after it became clear that the original design was unaffordable in the massive post-2008 recession. The developer, Forest City Ratner Companies, turned to New York's SHoP Architects and its sister company SHoP Construction, collectively known as SHoP, to create a stunning-yet-affordable solution.

SHoP Architects' response was not simply to fulfill the design assignment, but to apply the Dassault Systèmes (3DS) **3D**EXPERIENCE application for virtual product design, CATIA, to enable collaborative construction planning and execution. SHoP Construction (SC) became integrally involved in the fabrication process and in providing the comprehensive information required for construction management on site, using the highly detailed 3D model it developed in CATIA.

"SC stepped in to create the fabrication packages with its model," said Bob Sanna, executive vice president for construction and design development at Forest City Ratner. "If we had to interpret all this geometry using traditional tools, I'm convinced it would have taken triple the time."

In a compelling twist, the panel fabricator went bankrupt before the first panel was produced, and the project lost some of its engineering team. "There was a period of almost six months when we didn't have those participants," Sanna said. "To be able to make that up and bring the project in on time was amazing." In addition to countless hours of work by a committed and creative project team, Sanna gives much of the credit for that success to the use of 3D design and project planning tools.

Overcoming adversity

The journey to build Barclays Center was long and, in some cases, painful. The arena itself is the centerpiece of a large public/private mixed-use development called Atlantic Yards, originally planned by Gehry Partners more than half a decade ago.

Despite early enthusiasm, the project became bogged down when the 2008 housing collapse hit the economy, just as the arena budget topped $1 billion. Ratner decided it was time to go back to the drawing board. Or, more precisely, to the computer. SHoP uses computer-aided design technologies to produce innovative architectural forms, streamline the design and construction process, and simultaneously create new efficiencies and cost savings.

Key to its role, and indeed to its overall approach, is the firm's reliance on CATIA, a **3D**EXPERIENCE application. In the Barclays project, the CATIA model evolved over time, from representational architectural design to a highly detailed 3D construction model and, ultimately, to fabrication data fed directly to computerized numerical control (CNC) machines used to mill the steel panels for the façade.

CATIA provided a collaborative platform for the management of highly complex information. Through process innovation in CATIA, we enhanced the design and automated our fabrication workflow.

Jonathan Mallie, Principal, SHoP

The facade of the Barclays Center features 12,000 pre-weathered steel panels, each different in size and curvature. The **3D**EXPERIENCE Platform and CATIA application were instrumental in managing the resulting complexity of design, fabrication and installation. (Photo here and on cover by Bruce Damonte)

The model was used to coordinate all of the arena's Mechanical, Electrical and Plumbing (MEP) systems, and to produce automated quantity takeoffs for materials. It also enabled the construction team to identify and track each of the 12,000 façade panels and gave the team a real-time model of the façade's status during construction.

CATIA facilitates design exploration

Early in the process, SHoP's architects explored multiple design options. "We developed more than 100 combinations for various elements of the façade," explained Jonathan Mallie, a principal of SHoP and managing director of SC. The model enabled not only an assessment of design aesthetics, but also the impact of various alternatives on cost.

A final design was approved in September 2009, with fabrication slated to begin the following January. That left SHoP Architects' designers little time to develop the model's detail.

To move forward quickly, the designers leveraged the CATIA application's Knowledgeware component, which automates complex knowledge or processes for automated re-use, eliminating the potential for human error. "Knowledgeware is a way to create an automated workflow—in this case, to add layers of complexity that turn the schematic design and patterning model into a fabrication quality model," said John Cerone, director of Virtual Design and Construction for SC.

Initially, SHoP Architects' design team created patterns of panels without any connection details, using square footage as the primary constraint. Then SC added constraints and slot detail for the attachment of panels to the underlying lattice frame rails. At each step, part definitions were updated in the model.

"We had control over every single panel, every single support element in the façade," SC Senior Project Manager Brian Sweeney

Knowledgeware is a way to create an automated workflow—in this case, to add layers of complexity that turn the schematic design and patterning model into a fabrication quality model.

John Cerone, Director of Virtual Design and Construction, SHoP Construction

noted. Thanks to the workflow developed in Knowledgeware, the process was not linear; panels evolved in parallel, saving time that could be used to facilitate increased complexity, which in turn contributed to a more sophisticated design.

"If we had been constrained into using a linear process we might have worked with eight or ten different-sized panels," Sweeney said. "Instead, we were working with data that the fabricator would use to produce 12,000 completely unique panels, each one with a different size and bends."

From design to fabrication

The original façade design from SHoP Architects called for roughly 230,000 square feet of weathered steel for the façade, at a cost of nearly $30 million. Working through a matrix of design options in CATIA, SC optimized the design to use just 150,000 square feet of material — substantially reducing the cost. Individual part definitions from the model were passed along to the fabricator, making it clear exactly what size metal sheet was needed for each part.

"The fabricator normally assumes a certain level of material waste," Sweeney said. "As we worked with the nesting pattern, we were able to nest the panels and run various options in the model to optimize material use."

The part definitions were exported from CATIA into computerized CNC code for cutting. Then each panel was bent based on its unique geometry, again from the detailed 3D model.

Model enables tracking, communication

Creating 12,000 individual panels is one thing. Coordinating the orderly flow of finished pieces to the worksite and ensuring their proper placement on the building was yet another daunting challenge for Hunt Construction Group, the arena's builder.

"Traditionally, contractors want everything standardized and replicated, because that has been the most efficient way to build," said Jeff Fisher, contract manager for Hunt Construction. "Having 12,000 unique panels breaks the rules. Thank goodness we had a solution for managing the process."

To organize the components of the façade, the individual steel panels were grouped into "megapanels"— measuring roughly 10 x 50 feet — each incorporating multiple steel panels and the steel substructure on which they were mounted.

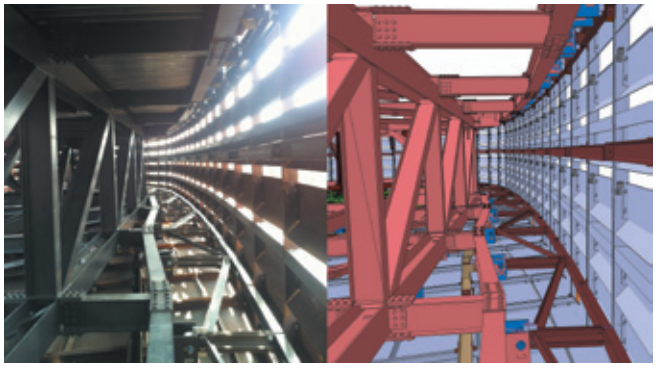
Every individual panel had a unique barcode ID scored into its reverse side. For each megapanel, the CATIA application provided all of the information required for assembly, including a bill of materials, tracked by the unique identifier of each panel.

To help monitor progress on construction of the façade, SC created an iPhone app that updates a database for tracking each panel. Throughout the fabrication and construction process, the app allowed the project team to follow the status of each panel as it was cut, formed, weathered, assembled onto a megapanel, and positioned for installation on site. A visualization application gave the on-site construction team a real-time graphic representation of the façade's status.

The 3D CATIA model also facilitated communications and collaboration among teams working in various areas. "We had teams in three locations: the office in New York, the fabricator in Indianapolis, and on site," Mallie explained. "The model was shared between sites and served as a reference for everyone involved."

That included not just the SHoP teams, but players throughout the project. The 3DS model integrated with other models already established for the project by Ellerbe Becket Architects & Engineers and structural engineer Thornton Tomasetti. "The model made people very comfortable in proceeding with design development," Forest City Ratner's Sanna said. "If we hadn't had the model, it would have taken longer to get people moving forward with the whole process."

Detailed 3D design in CATIA allowed SHoP to clearly communicate design intent, guide assembly, and generate accurate material takeoffs that reduced waste materials and cut costs.



SHoP Architects' facade for the Barclays Center in Brooklyn was hailed by *The New York Times* as "muscular and progressive, like its borough." Together with its sister company, SHoP Construction, the team cleared numerous hurdles to bring the project in on time and on budget. (Photo by Bruce Damonte)

In the end, the arena was completed in time to host an opening-night concert by Jay-Z (an owner of the Nets) in September 2012, and to host the Nets for the start of the 2012-13 season. Many of the companies involved in building the arena have now moved on to the design and construction of other pieces of the larger Atlantic Yards project.

A new direction for AEC

Jeff Fisher of Hunt Construction cites the Barclays Center project as a good example of how 3D modeling can help transform the construction process. "Large-scale construction can be difficult in a business with lots of variables," Fisher said. "But 3D modeling technology and its collaborative tools, allowing everyone involved to visualize what you're working to create, is a breath of fresh air. That's where the industry is going."

Sanna agrees. "We couldn't have built this facility without the 3D model," he said. "3D modeling has allowed the industry to become more precise so we can fabricate offsite, more accurately and more cost-effectively. Without the model, this would have taken longer and cost more."

Cerone and Sweeney of SC see 3D modeling as a means to help view projects in a holistic way, always thinking from beginning to end, with the goal of total control over a project's finest details. "We do not like unknowns," Cerone said. "We do not like things that are out of our control. We want to build in as much information as possible."

In this sense, 3D modeling is an enabling technology to move firms from a traditional architectural role into the role of process engineer for construction.

As Stephen Kieran and James Timberlake wrote in *Refabricating Architecture: How Manufacturing Methodologies are Poised to Transform Building Construction*, "...while the world of architecture has grown ever more wasteful, disposable, splintered and specialized, the process engineer flourishes in the fluid integration of makers by dissolving, not reinforcing, boundaries between thinkers and makers."

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