A Model Museum

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Extensive 3D modeling helped to create and navigate the framing for a new art museum in Virginia.

MOVING TO NEW FACILITIES SEEMS TO BE PART OF THE 21ST CENTURY AMERICAN WAY OF LIFE. Offices, hospitals, and professional sports teams seem to do it all the time. But it's a rarer occurrence for art museums.

The Art Museum of Western Virginia in Roanoke, Va. is embarking on such a move. And, it's getting a new name. The new Taubman Museum of Art, the Art Museum of Western Virginia's new incarnation, will open this fall. The 82,000-sq.-ft facility will house the museum's permanent collection and greatly expand its exhibition and education spaces. As the city's most contemporary structure, it represents Roanoke's metaphorical gateway to the future for a city transforming its industrial- and manufacturing-based economy to one driven by information technology and services.

The new museum's forms and materials interpret the renowned beauty and drama of the Shenandoah Valley and the adjacent Blue Ridge and Appalachian Mountains. A dramatic, spacious atrium that rises to a peak of 75 ft is the hub of the entire facility, while angular exterior walls rise to support a curving roof whose various textures and forms emphasize the rocky surfaces found in the region's caverns, cliffs, and river gorges.

Scheming in 3D

Structural steel forms the curving roof forms and steel framing is featured as an architectural element in the atrium lobby. The floor levels, while irregularly shaped in plan, each have a constant floor elevation, and were therefore framed using conventional methods. Initially, both steel and concrete floor systems were considered, but a large number of transfer girders and tight floor-to-floor height requirements resulted in steel being used for this portion of the project as well.

The curving roof forms and other complex surface geometries necessitated the use of a 3D modeling program in order to accurately convey the required member work points and geometry to the design and construction teams. Several programs were considered but the design team chose Rhino, which can create, edit, analyze, document, render, animate, and translate NURBS (non-uniform rational B-spline) curves, surfaces, and solids. It proved indispensable from schematic design, through the design stage and into construction administration, when various Rhino files were provided by DeSimone and project architect Randall Stout Architects (RSA) as part of the construction document package.

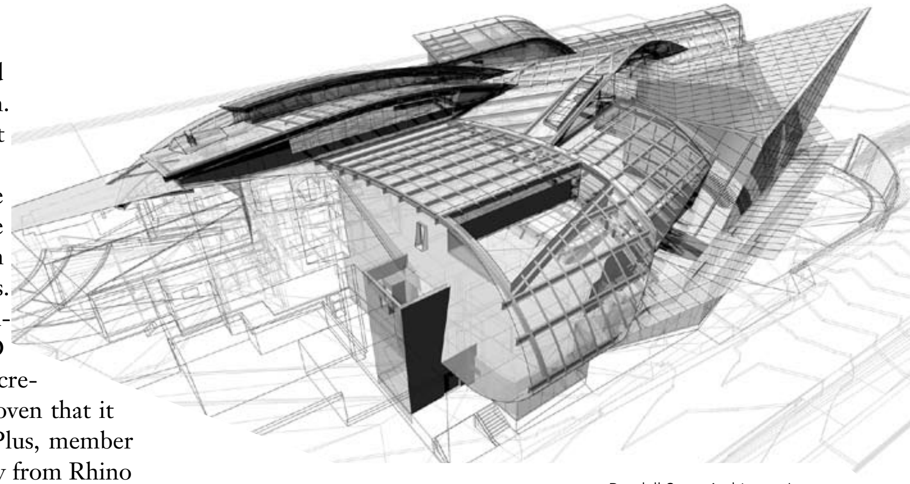
During schematic design, RSA used Rhino to investigate various geometric forms. These architectural models consisted of the curved exterior surfaces, which could be offset to define the top of the steel elevations. The museum's roof consists of several distinct curved surfaces, though each individual surface has a single radius, which greatly simplified construction and reduced fabrication costs. Despite the visual geometric complexity of the roof, its curving shape was achieved with a straightforward structural framing

Randall Stout Architects, Inc.

The Art Museum of Western Virginia's lobby atrium features nine architecturally exposed W14 structural steel columns that each slope 23° from vertical.

system; curved WT4×17 joists spaced at 6 ft supported a metal roof deck that curved in its weak direction. The WT4×17s in turn were supported by straight beams that framed into kinked girders.

Finding column locations that worked with the roof geometry, and that did not interfere with the gallery space below, was a challenge that resulted in numerous column transfers and cantilevered beams. To keep track of the multiple load path transitions running vertically down the building, a single RISA-3D model with both gravity and lateral members was created. Past project experience with RISA-3D had proven that it could accommodate unusual building geometries. Plus, member locations and orientations could be imported directly from Rhino using .dxf files. The composite floor slabs, in turn, were designed using RISAFloor, which seamlessly integrates with RISA-3D.



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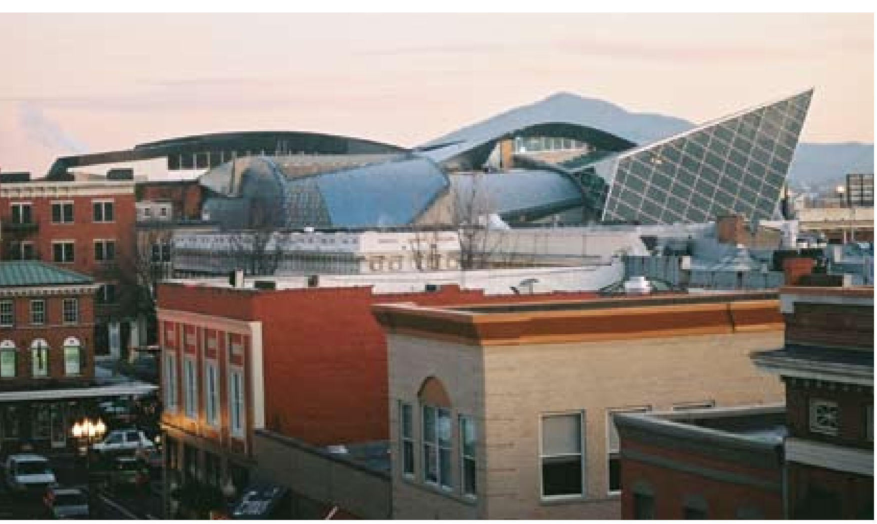
During the detailing stage, the structural Rhino model was provided to the steel detailer, Superior Steel, who imported the steel members into the detailing program SDS/2. Due to the unique challenges posed by the building's geometry, the design and construction teams decided to submit and review "shop models" prior to the creation of shop drawings. After the steel detailer completed detailing a portion of the structure in SDS/2, the model was then converted back into a Rhino model and provided to the design team for review. The shop model review was primarily to review member geometries and to identify conflicts with architectural surfaces and building systems; verification of member sizes and connections were done later in the shop drawing phase. Both DeSimone and RSA formally commented on the shop models using Rhino's "dots" and "notes" features, in which members were "tagged" with text dots, directing the detailer to the appropriate comment in the Notes section. If geometry revisions were required by the design team, the affected structural members were remodeled, placed on a separate layer, and highlighted in red—the shop model version of the cloud and delta procedure used for 2D drawings , in which drawing changes are clouded and marked with a revision number.

Shop models were also reviewed by the glazing and cladding subcontractors, whose secondary support members attached to the structural steel. During each shop model review period, the design and construction teams, which were scattered across the country, conducted web conferences using Webex, a technology that allows participants to share and view each others' desktop applications. Webex enabled the architect, structural engineer, general contractor, steel detailer, and glazing and cladding subcontractors to simultaneously view a single shop



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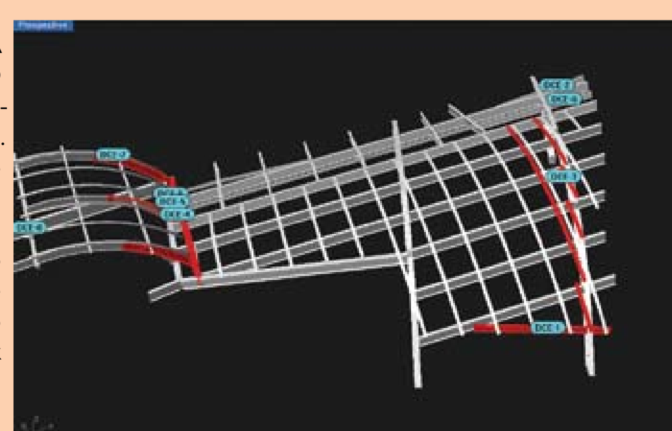
The museum's exterior is intended to echo the surrounding area's geological features.

FROM 3D TO 2D

To fully convey the building geometry to the construction team, both RSA and DeSimone provided Rhino models in addition to conventional 2D drawings. RSA's Rhino models contained information such as the exterior surface geometries, mullion patterns, and top-of-concrete elevations. DeSimone's Rhino model contained solid and wireframe modeling of the roof and atrium steel members. The 2D structural drawings contained framing plans, column schedules, sections, and details as would be found in a typical construction drawing set. Only by also providing a Rhino model could geometries such as the curve of the WTs and the kink of the roof girders, be defined. Besides being a powerful visual tool, Rhino also proved useful in creating 2D axionometric views of the more complex geometric forms. (Using the "Make2D" command, Rhino can flatten a model's current view into a series of lines, which can then be imported into AutoCAD to create elevations and details.)



DeSimone Consulting Engineers.

model. In this manner, conflicts were identified and resolved quickly by all affected parties.

The Atrium, "Knuckle," and Theater Cantilever

The lobby atrium posed a unique structural challenge for DeSimone. It features nine architecturally exposed W14 structural steel columns that each slope 23° from vertical. To stabilize the atrium columns and essentially keep the atrium from tipping over, 2-in.- and 3½-in.-diameter pretensioned rods pull the peak of the atrium and tie it down to the rest of the structure. A continuous ring of HSS22×20 beams further stabilize the atrium columns and support the glazing system, which hangs from the ring using a series of pre-stressed cables that match the slope of the atrium columns. DeSimone performed a non-linear analysis of the roof diaphragm, which consists of 2-in.-diameter pretensioned cross-rods that span between the HSS22×20 beams. Pretensioned rods also span between the atrium columns to provide weak-axis lateral support.

Just northeast of the lobby atrium is a portion of the structure referred to as the "knuckle" in which a conical surface spans vertically between the second and third floor levels. This conical surface, along with several other unusually shaped exterior surfaces, uses ZEPPS, an engineered panel system created by A. Zahner Company, the cladding subcontractor. ZEPPS panels can take on any shape, curve, or bend and are prefabricated in the shop, eliminating the labor-intensive field fabrication associated with build-in-place systems. At the knuckle, the use of ZEPPS meant that a single conical panel needed to be attached to the primary steel structure, which greatly simplified construction and resulted in a better quality building envelope.

Another striking feature of the museum is the "theater cantilever" at the southeast corner of the building. As its name implies, the theater cantilever is supported at the second floor level by a series of W33 beams that cantilever dramatically over the exterior sidewalk. Transfer columns supporting the third floor framing sit on the tips of these cantilevered beams, while HSS "arms" cantilever from the transfer columns to support the curved surfaces that wrap the theater cantilever. Similarly, complex load paths occurred throughout the building structure, requiring careful analysis and evaluation of expected construction sequences and vertical displacements. MSC

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