Has intent become reality?

Visionary architecture is now buildable, thanks to Smart Geometry

Imagine a 280-meter bridge supported by a stainless steel double-helix exoskeleton. Arup executed the archetypal design for the Marina Bayfront Pedestrian Bridge in Singapore by modeling the curved geometry to use less steel. Now picture the undulating form of a 23,000-square-meter roof clad in transparent and translucent polycarbonate. HOK Sport fine-tuned the complex structure for Dublin's Landsdowne Road Stadium using a parametric model to minimize the components. Now envision a walk through a light-infused educational centre shaped like a Damask rose. Henning Larsen Architects optimized the petal-shaped design of the Massar Children's Discovery Centre in Damascus, Syria, so it could be built by local contractors.

Visionary architecture around the world has became a reality thanks to advances in smart geometry - made possible by a computing process alternatively known as parametric modeling, computational design, or generative design. The process allows architects and engineers to use rule-based design parameters and geometric relationships to create complex building components, then automatically apply changes in the parameters throughout the models to test the constructability of their designs.

"In generative design, architects and engineers are achieving results and designs that were virtually unthinkable before," said Buddy Cleveland, senior vice president, Bentley Applied Research Group. "They have upgraded from using computers to simply speed the drawing process to employing immense computational power to discover their ideal design."

Generative design enables architects

and engineers to describe design components and relationships using elegant, powerful algorithms. As the design progresses, a change to one component in the system automatically drives changes to other related components. Using this approach on even the most complex structures, designers can quickly explore a broad range of alternatives, speed their design iterations, and generate designs that are freer in form, more efficient, and more fit for purpose.

Bentley's GenerativeComponents uniquely preserves and exploits the critical relationships between design intent and geometry. Users can, for instance, dynamically model and manipulate geometry, apply rules and capture relationships among geometric features, and define complex forms through concisely expressed algorithms. When used as an extension of MicroStation, GenerativeComponents produces generative designs that can flow through to detailed production and fabrication without information loss.

GenerativeComponents software arose from a research project led by a Bentley director of research whose work attracted expert input from a network of elite early adopters. As the software solidified, the research transitioned to commercial product development led by Bentley Software. The Bentley developers continued to collaborate with the network of early adopters, who coalesced into the independent Smart Geometry Group. Bentley released GenerativeComponents as a trial program for generative design in architecture and engineering in November 2007.

Since then, the SmartGeometry Group has remained dedicated to educating the construction professions in the new skills required to effectively use advanced design systems such as GenerativeComponents. The directors of the SmartGeometry Group include Lars Hesselgren of Kohn Pederson Fox (KPF), Hugh Whitehead of Foster + Partners, and J. Parrish of Arup Sport.

KPF's Bishopsgate Tower, also known as "The Pinnacle," was the first major building to be approved for construction with a form completely designed and developed using GenerativeComponents. Construction of the 60-story building commenced in 2008 and, upon completion in 2010, The Pinnacle will become the tallest building in London.

"KPF has been using GenerativeComponents for some time, forming a key component in the armoury of the KPF Computational Geometry Group," Hesselgren said. "Several of our most advanced projects employ GenerativeComponents as a tool for exploring thousands of options as well as the complex geometry to be used in final construction, all ultimately benefiting our clients."

Given the project's $35 million budget, construction of the 15,000-square-meter Massar Children's Discovery Centre would not have been possible without using parametric modeling to visualize the rose-inspired design. Henning Larsen Architects, based in Copenhagen, Denmark, used Bentley Architecture and Bentley Structural software to design the multipurpose facility, which includes exhibition, library, education, and administrative space.

GenerativeComponents created the complicated geometry of the petal-shaped areas, which were a crucial part of the design concept articulated in the client brief. "Not only did we have to design them to fit with the client brief, but we also had to optimize them for construction and communicate the complicated forms to local contractors," explained Birte Baek, CAD manager at Henning Larsen Architects.

From the initial sketch of the Damask rose, the software allowed the team to draw the shapes free of any preset geometrical constraints. Throughout the development, the team then refined the design to work within budget and simplify construction of the complicated petal surfaces. In essence, Baek said, using GenerativeComponents made the landmark project possible. The award-winning design was completed in 2006 and construction will be complete in 2010.

Empowered by computational methods, designers can direct their creativity to deliver inspired sustainable buildings that are freer in form and use innovative materials and assemblies. GenerativeComponents facilitates this by allowing the quick exploration of a broad range of what-if alternatives for even the most complex buildings.

This unique generative design software captures and exploits the critical relationships between design intent and geometry. Designs can be refined by either dynamically modeling and directly manipulating geometry, applying rules and capturing relationships among building elements, or defining complex building forms and systems through concisely expressed algorithms.

GenerativeComponents is integrated with Bentley's building information modeling, analysis, and simulation software, providing feedback on building materials, assemblies, systems performance, and environmental conditions. This integration also ensures that intent becomes reality by enabling designs to accurately and efficiently flow through to detailed production and fabrication.

As architects and engineers become more adept at smart geometry, ingenious designs like rose-shaped buildings, asymmetrical stadium roofs, and double-helix bridges will become common landmarks around the world.

www.smartgeometry.com
www.bentley.com/generativecomponents