RhinoCAM at SDSU

South Dakota State University Department of Architecture

South Dakota State University, located in Brookings South Dakota includes the College of Arts & Sciences where students prepare for degrees in technical studies including Architecture, Design, and Aerospace among others.

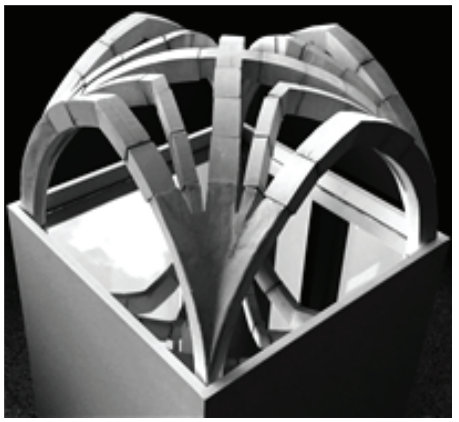
We recently sat down with Jessica Garcia Fritz and Franklin Parker who agreed to share with us their experiences in the use of RhinoCAM at the SDSU workshop in support of student design/build projects.

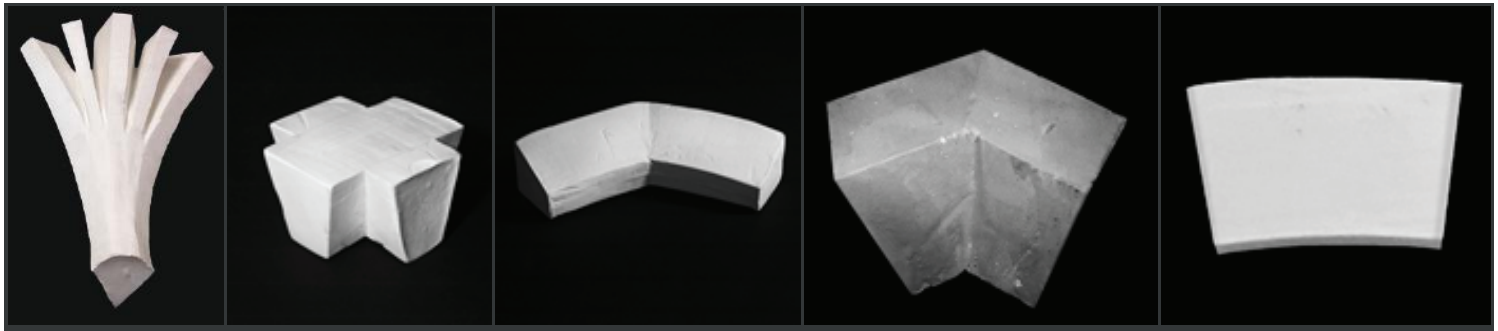
Jessica Garcia Fritz

Jessica is a full-time Assistant Professor in the Department of Architecture at SDSU where she teaches design studio, architectural history, and a building workshop. Her current research focuses on Gothic Vaulting and Timbrel Vaulting technologies. Jessica earned her Bachelor of Arts in Architecture and a Master of Architecture from the University of Minnesota, School of Architecture, where she was a finalist for the Richard Morrill Memorial Thesis Award for Design Excellence. Following graduate school, Jessica worked as an intern architect in New York City working with the Smithsonian's National Museum of the American Indian (NMAI) where she gained experience in the design and construction of museum exhibits with a socio-cultural and historical focus.

The "Tas-de-charge" Project

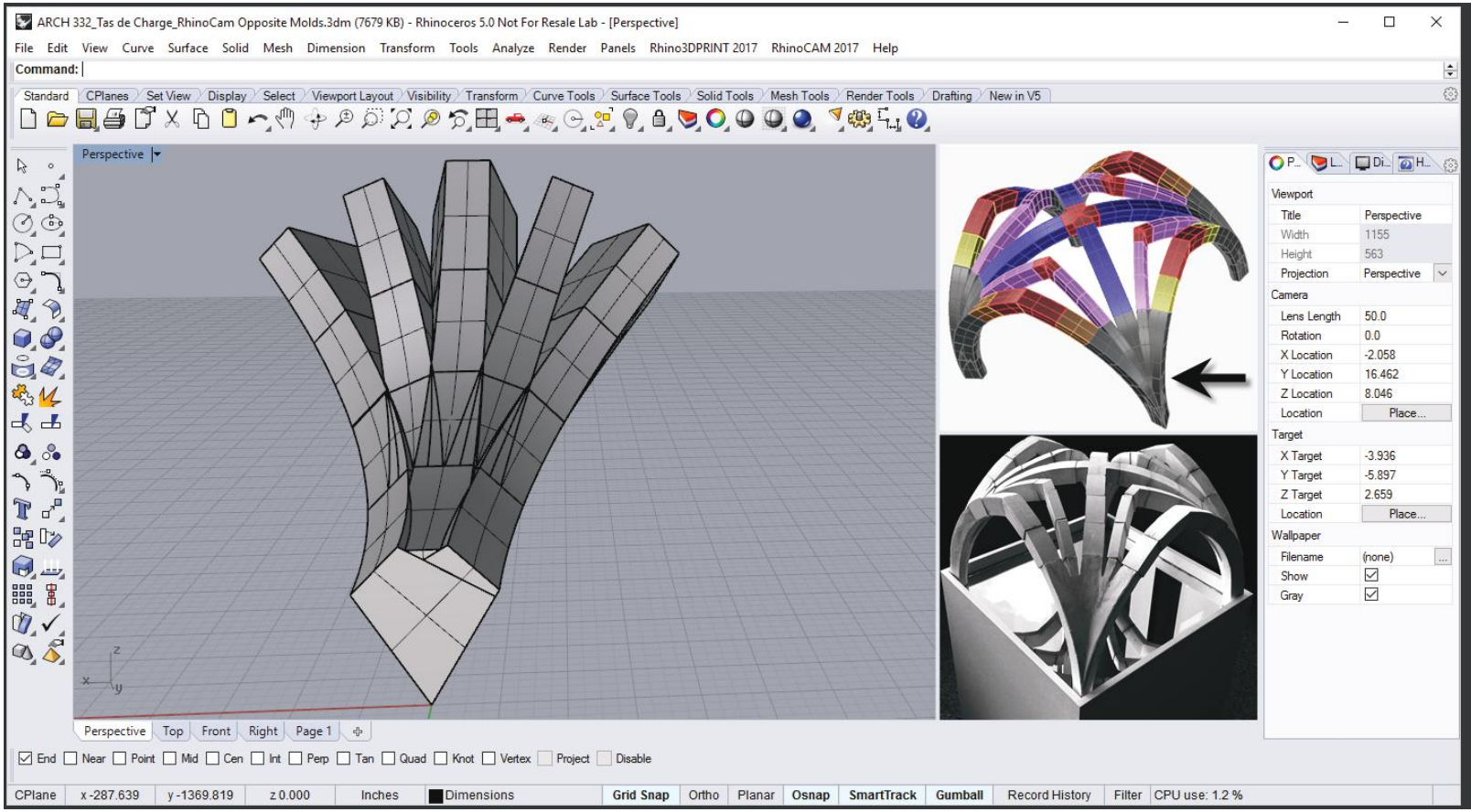
Tas de charge is a French language term that refers to the lower courses of ribs of a Gothic vault structure. In Jessica's class (ARCH 332: Building Shop), students will understand the principles, tools, and technologies that contribute to Catalan, Funicular, and Gothic forms of vaulting. Students demonstrate this understanding through the assembly and fabrication of both digital and physical models of vaulting systems. In Rhino Jessica has modeled the example Gothic Ribbed Vault structure (shown here) that she uses in the class.





The 5 components of the gothic vault structure (Tas de charge, Boss, Keystone, Terceron Keystone, and Voussoir)

Here are the 5 components of the vault structure from left to right (Tas de charge, Boss, Keystone, Terceron Keystone, and Voussoir). While this is a group project, each student has access to the actual Rhino parts and assembly for 3D modeling and RhinoCAM for programming toolpaths on the school's 3 Axis Techno CNC machining center. Since the Tas de charge is the most complicated piece, we have selected it for further discussion below.

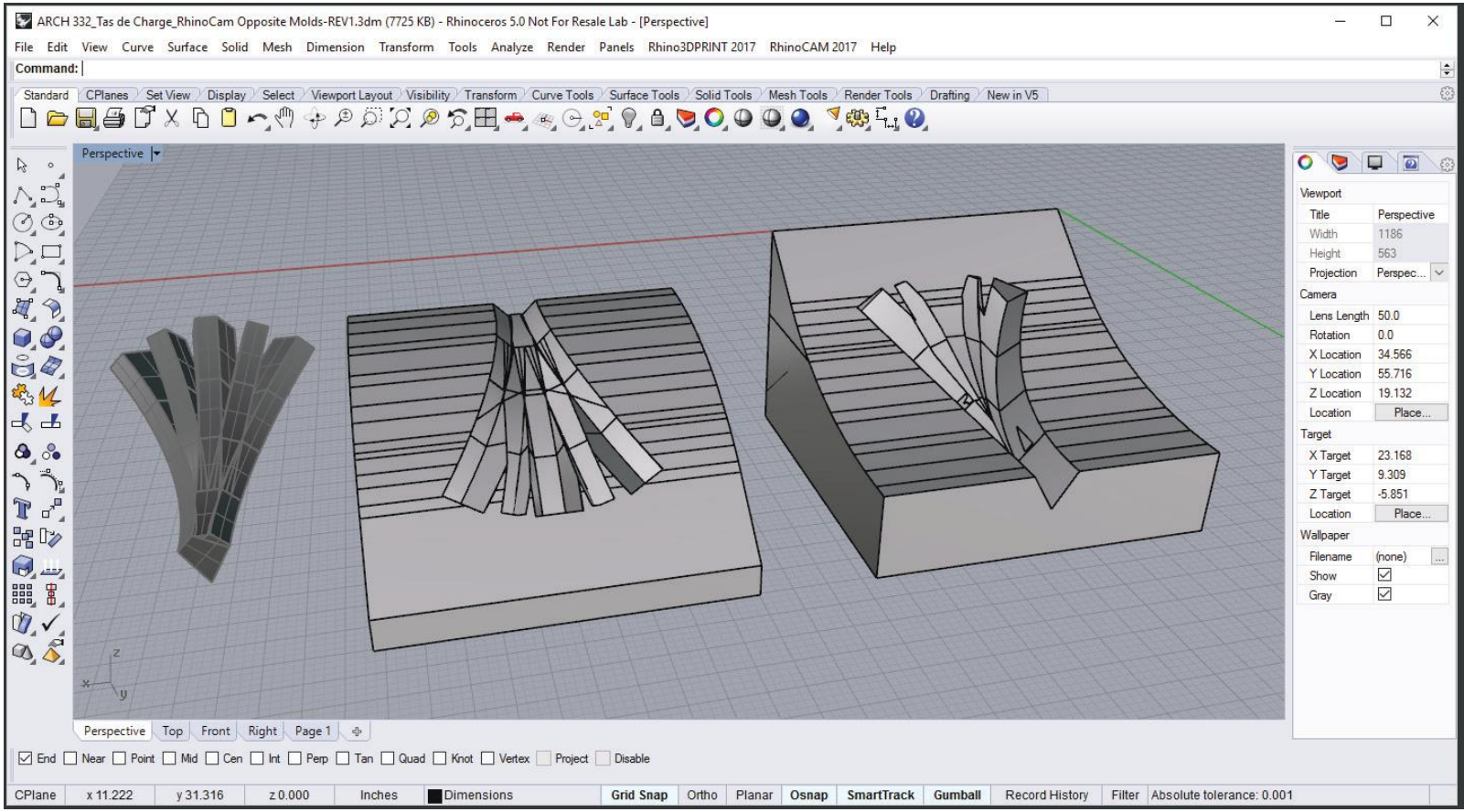


(Main Image) The Tas de charge 3D model in Rhino

(Right Top) The 3D assembly of the Gothic vault

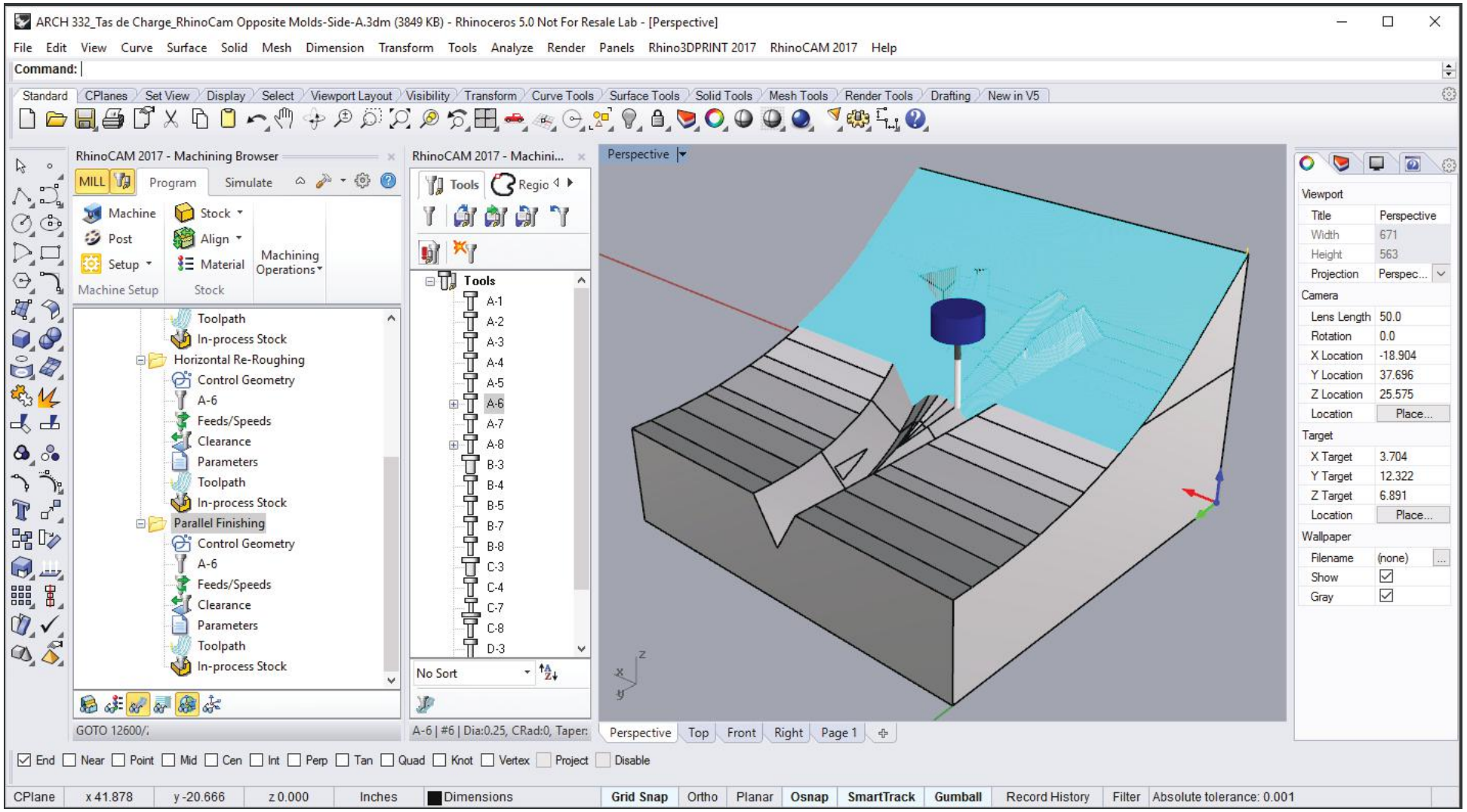
(Right Bottom) The final Gothic vault structure designed and assembled by Jessica's students!

In the Rhino display above we see the Tas de charge 3D model and its position within the Gothic Ribbed Vault structure. In vaulting architecture, the Tas de charge is the key component that supports the weight of the structure. In the Rhino display below we see how the part is used to model the upper and lower cavity halves of a mold used to cast the part.



Here we see the Tas de charge 3D model in Rhino along with the 3D models of the upper and lower mold cavities used to produce the part.

In the RhinoCAM display shown below, we see a 3 Axis Parallel Finishing toolpath being simulated on the lower cavity of the Tas de charge mold. From left to right we see the RhinoCAM Machining Browser, the RhinoCAM Machining Objects Browser (showing the shop's library of tools) and then the part model and toolpath display.

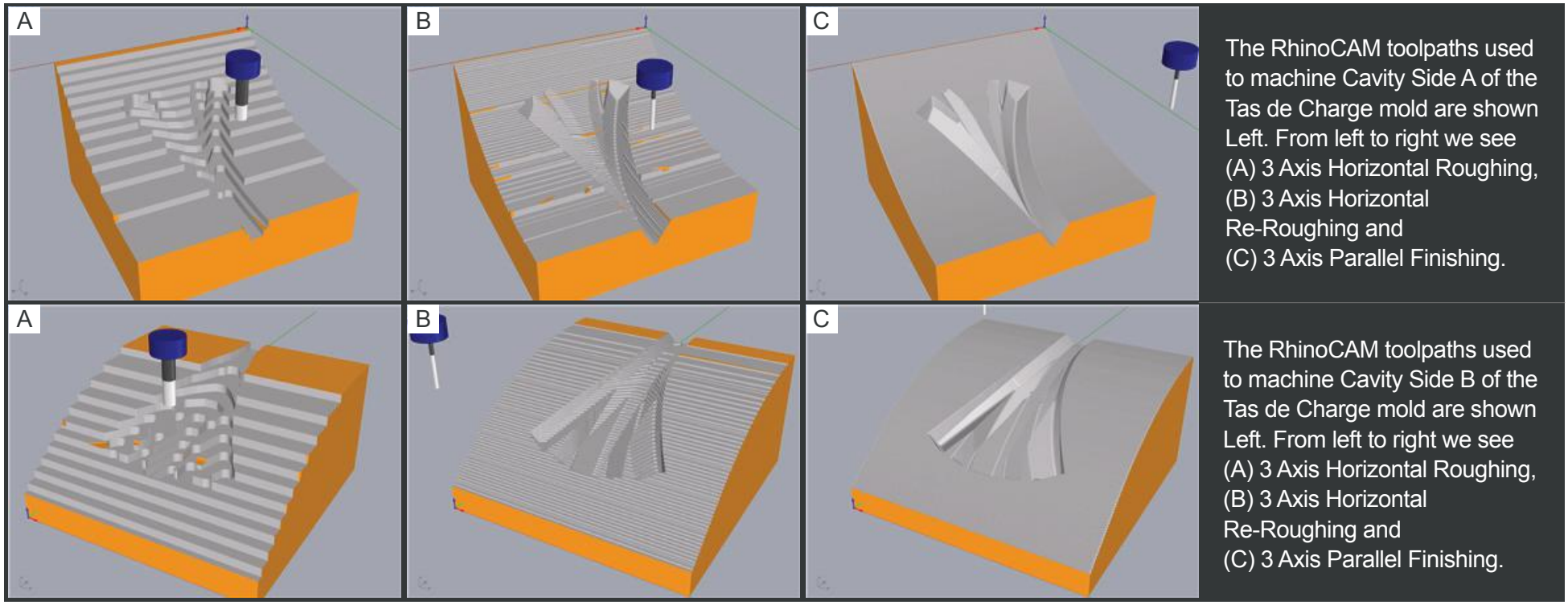


The RhinoCAM plugin is loaded showing the Machining Browser, Machining Objects Browser with Tool Library and the 3 Axis Parallel Finishing toolpath simulation for the lower cavity of the Tas de charge mold.

One of the concepts we teach students in the use of digital fabrication is the difference between the 3D model and the resulting part that comes off the CNC machine. During this hands-on process, the students learn both the limitations and the benefits of the technology.

- Jessica Garcia Fritz, Assistant Professor in the Department of Architecture, SDSU

The series of RhinoCAM display images below shows the toolpath cut material simulations for each cavity half of the Tas de charge mold. Notice the progression (from left to right) of 3 Axis Roughing, Re-Roughing and Finishing operations. In 3 Axis Re-Roughing, the cut material simulation of the previous Roughing operation is used as the in-process stock for calculating the re-roughing toolpaths using a smaller tool diameter. This optimizes machining time by eliminating wasted tool motions.



The RhinoCAM toolpaths used to machine Cavity Side A of the Tas de Charge mold are shown Left. From left to right we see (A) 3 Axis Horizontal Roughing, (B) 3 Axis Horizontal Re-Roughing and (C) 3 Axis Parallel Finishing.

The RhinoCAM toolpaths used to machine Cavity Side B of the Tas de Charge mold are shown Left. From left to right we see (A) 3 Axis Horizontal Roughing, (B) 3 Axis Horizontal Re-Roughing and (C) 3 Axis Parallel Finishing.

Group Assembly of the Vault

Here are some images of Jessica's class assembling the Tas de charge and the other components of the vault. Enjoy!

More about ARCH 332: Building Shop II at SDSU

To learn more about Jessica's class and the Department of Architecture at SDSU we invite you to visit the following links:

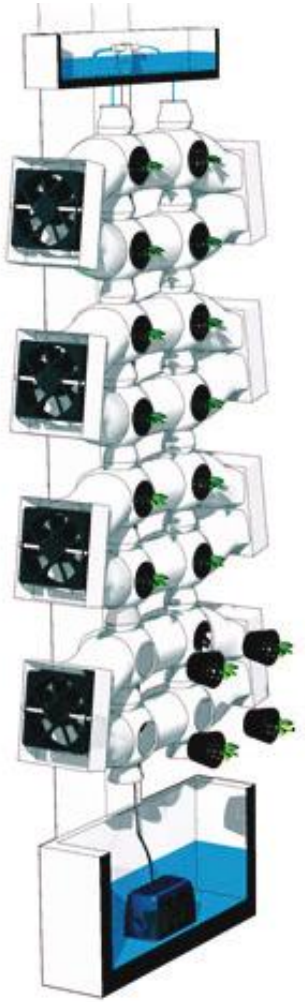
- The South Dakota State University home page
- SDSU Department of Architecture
- ARCH 332: Building Shop II class at SDSU (2015)

Franklin Parker

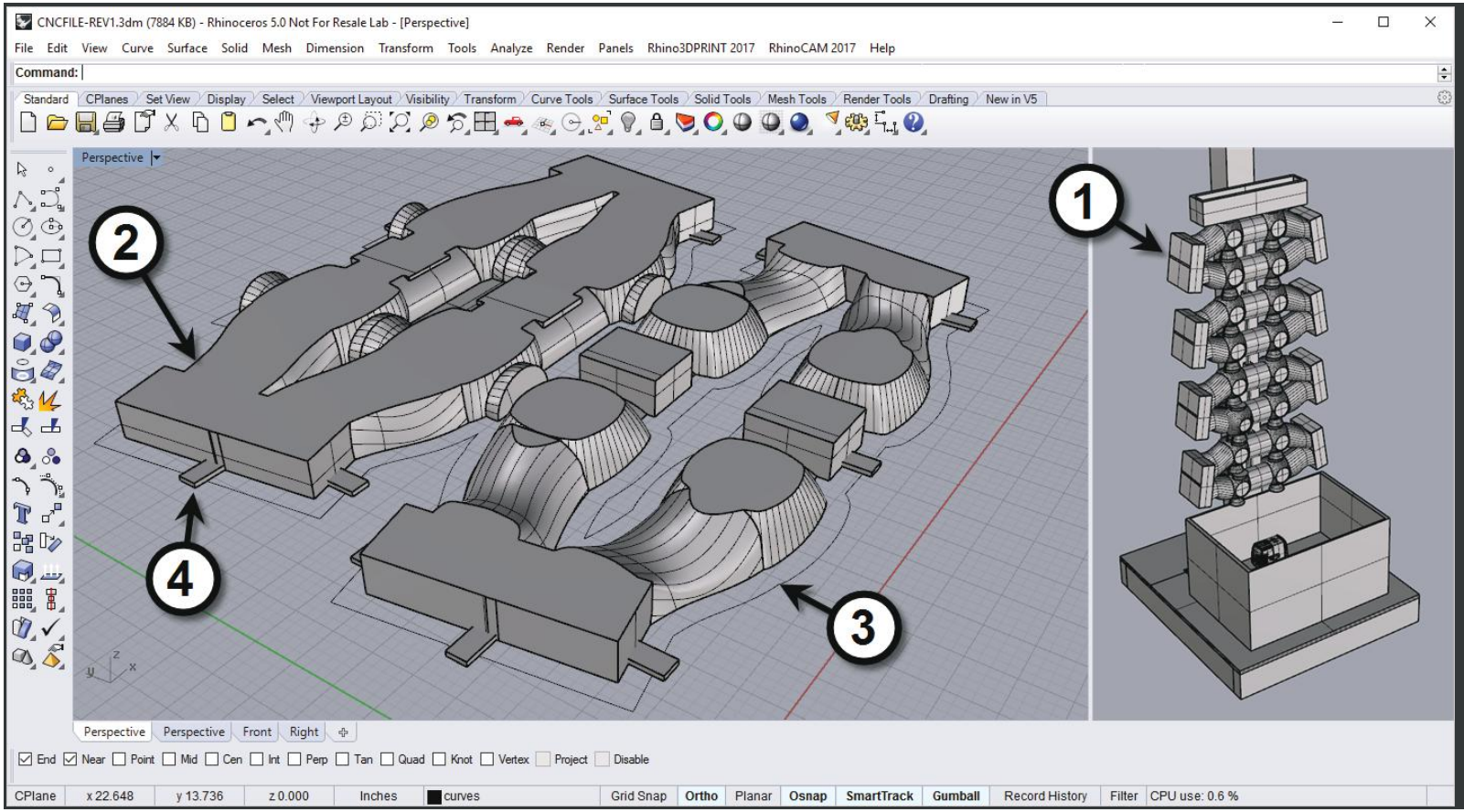
Frank is a double major (GIS & Architecture) undergraduate student at SDSU and works in the design/build shop on the campus where he oversees the operation of the school's Techno CNC machining center. Frank also teaches a bi-weekly course to certify students in CNC machine's safety and its proper usage.
Frank assists students and faculty on their design/build projects by performing 3D modeling in Rhino and preparing RhinoCAM toolpaths for machining. Frank is also working on setting up the shop's tool library standards in RhinoCAM for use by current and future students and faculty.

The Green Wall Project

Frank and the students designed and built a working hydroponic phytoremediation system, often referred to as a Green Wall. Phytoremediation is a process that uses living plants to clean contaminants in soil, air, and water. In the Drip System illustrated here, water is pumped from a holding tank below the wall up to a tank above where it is gravity fed from a drip line onto the plant's roots in each pod. Any excess water is recovered and recycled. Room air is ventilated through each pod cleaning pollutants like soot, sulfates, and organic particles, through a naturally occurring phenomenon called coagulation (the attraction of droplets and aerosols).

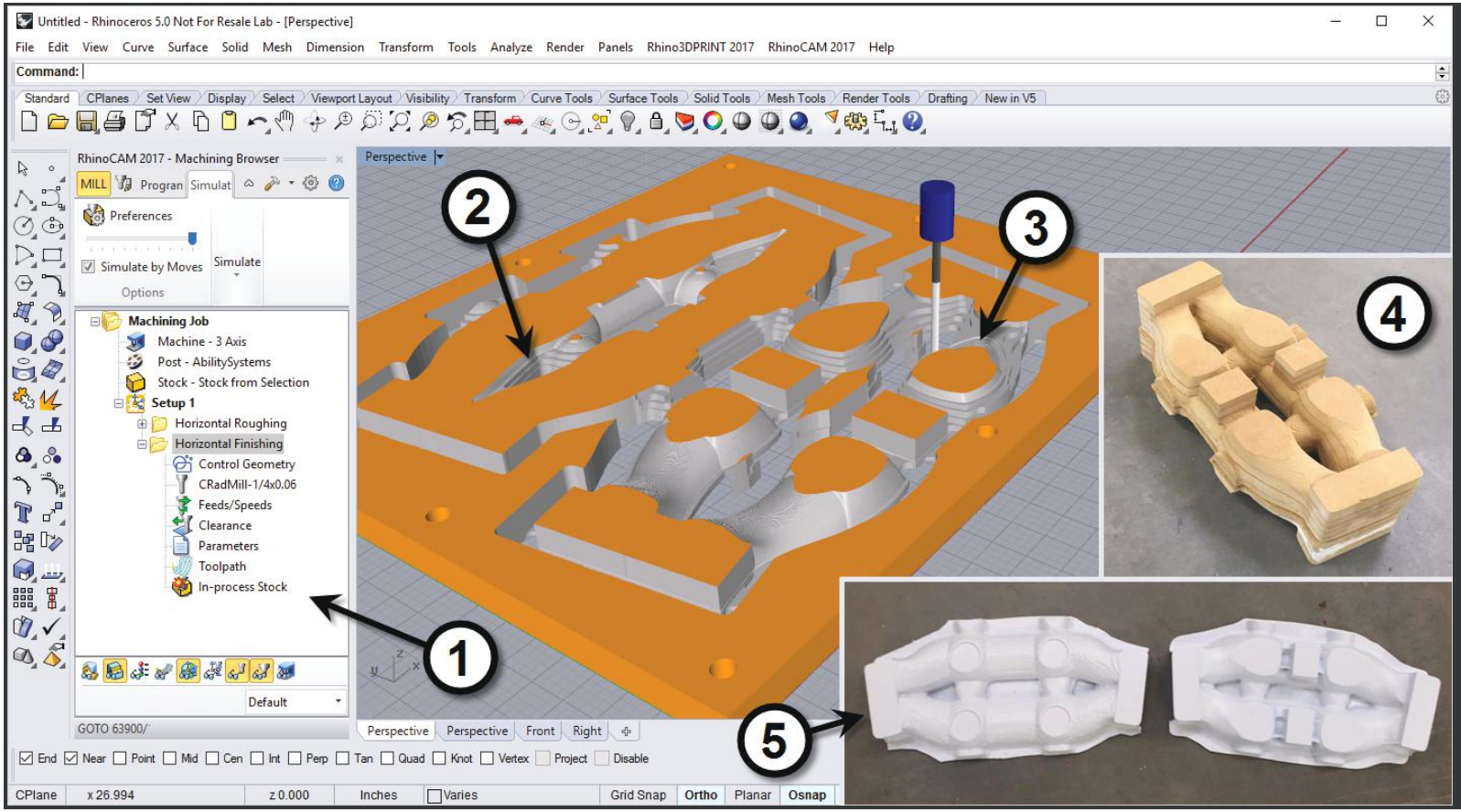


In this project, each pod was vacuum formed over a core. The core was machined from RhinoCAM toolpaths on the school's 3 Axis the Techno CNC machine center. The images below illustrate RhinoCAM's role in the design/build process.



The Green Wall 3D assembly in Rhino along with components for machining. Refer to the more complete description in the text below.

In the screen image above we see the complete assembly modeled in Rhino on the right (1). Each pod is a complete unit that is divided into 1” thick sections and laid out for machining. On the left, we see two of the sections positioned for machining (2). The offset outer boundary curves serve to contain the cutting to only the areas needed (3). Tabs were modeled on the XY plane that extend from the part out past the containment curves (4). These tabs will help fixture the parts to the stock on the bed of the Techno CNC machine.

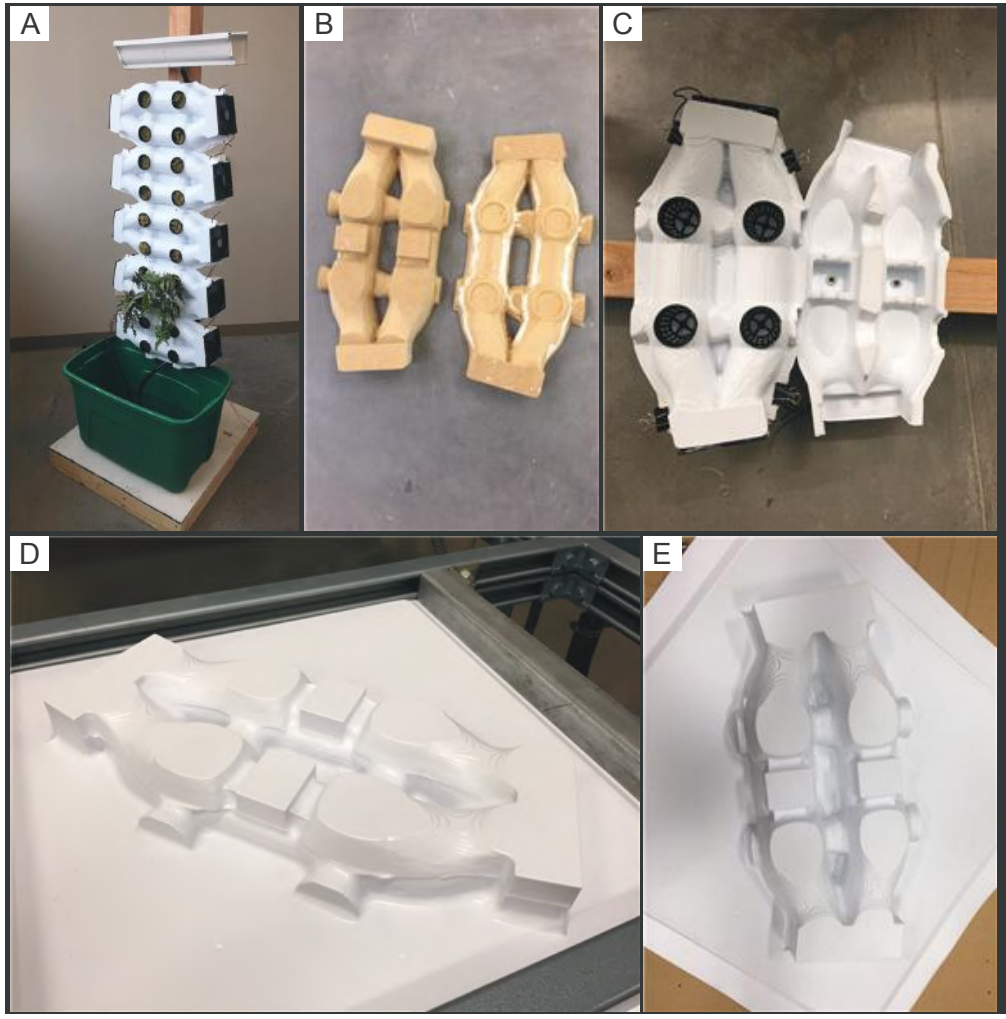


Toolpaths for a section of the Green Wall pod are displayed in RhinoCAM along with the pod core and resulting vacuum formed core halves. Refer to the more complete description in the text below.

In the screen image above we see the RhinoCAM Machining Browser displayed on the left with Setup 1 containing 3 Axis toolpath operations (1). First, 3 Axis Horizontal Roughing is used to clear stock material from around the part out to the containment boundary curves (2). Then 3 Axis Horizontal Finishing is the perfect toolpath choice for finishing the near vertical outer surfaces (3). After all, sections are machined, the core is assembled in two halves and then sanded. The core halves are shown here lying atop each other forming the completed pod (4). Each pod half is then vacuum formed over the cores. A completed set is shown here (5).

RhinoCAM is exceptional in many ways. The cut material simulation is exceptionally helpful for students to see and understand tool motions. I also like that RhinoCAM comes with a standard tool library and knowledge base that I can customize with the tools and feeds/speeds we use most often here in the shop.

- Frank Parker, Graduate Student, SDSU



A. The working hydroponic phytoremediation system.

B. The pod core models machined on the Techno CNC machining center from RhinoCAM toolpaths.

C. The core half being vacuum formed.

D & E. The resulting vacuum form prior to trimming.

More about RhinoCAM

RhinoCAM is available in 5 different configurations (Express, Standard, Expert, Professional, and Premium). The part shown here was programmed using the Professional configuration. Here are some additional details about each of the available configurations. Click here for the complete features list.

- **RhinoCAM Express:** This is a general-purpose program tailored for hobbyists, makers, and students. Ideal for getting started with CAM programming. Includes 2 & 3 Axis machining methods.
- **RhinoCAM Standard:** This is a general-purpose machining program targeted at the general machinist. This product is ideal for the rapid-prototyping, hobby and educational markets where ease of use is a paramount requirement. Includes 2-1/2 Axis, 3 Axis, and drilling machining methods.
- **RhinoCAM Expert:** Includes the Standard configuration plus 4 Axis machining strategies, advanced cut material simulation, and tool holder collision detection.
- **RhinoCAM Professional:** Includes the Standard and Expert configuration plus advanced 3 Axis machining strategies, 5 Axis indexed machining, machine tool simulation, graphical toolpath editing and a host of other features.
- **RhinoCAM Premium:** Includes the Standard, Expert and Professional configurations plus 5 Axis simultaneous machining strategies.

To read more about RhinoCAM and other MecSoft Corporation products including screen images, resources, and features lists, please visit our Product page. You can also demo our products to take them for a test drive.