

1:1 Rapid Prototyping

Successful development of each project's enclosure system design includes effective communication of engineering and performance strategies to clients, contractors and executives. Two-dimensional drawings and renderings may not convey the design elements which lay beyond the surface. Enter the 3D print. Three-dimensional full-scale prints offer a tactile and visual engagement which cannot be achieved without the physical model. Such prototypes also allow the design team to experiment with new ideas and numerous design iterations up-front avoiding costly oversights further into the project. A bolt assembly can be printed in hours, or a vertical mullion extrusion overnight. The physical model is more than a visual mock-up – the printed form acts as a functioning assembly with pieces able to snap together and verify design tolerances.

In fall 2009 the Studio acquired a Dimension 3D prototype machine to create on-site working models directly from CAD modeling tools. The prints are made of tough ABS plastic that can be sanded, milled, or even painted. The Studio currently has ABS plastic for 3D prototypes available in black, grey, natural, white, red and blue. Having the three-dimensional printer has proven extremely valuable in communicating design concepts while keeping Enclos design elements in-house.

INTRODUCTION

The term rapid prototyping refers to the automatic construction of physical forms using an additive manufacturing technology. This technique takes virtual designs from computer aided design tools (AutoCAD, Inventor, 3dsMax, Rhino, SolidWorks, etc.), virtually transforms the object into thin horizontal cross-sections, and successively layers the series of slices into a complete reproduction. By heating the plastic as each layer is placed, the printer is able to create almost any shape or geometric feature.

The printer uses companion software to feed interpreted virtual files to the machine. The data translation from the virtual CAD model and the printer's software is the stereolithography (.STL) file format. This file uses a triangular mesh approximation of the modeled part shape using many small facets to produce a high quality replication. Additive modeling systems vary greatly in the amount of time required to produce a print. The Dimension machine at ATS is able to produce full-scale mock-ups of components in a short period of time, but keep in mind, the term "rapid" is relative. The print duration depends on the size and complexity of the model, as well as the number of models being produced simultaneously. For example, a 12" extrusion of a vertical mullion section may range anywhere from 24-48 hours depending on the shape. Many of the models seen in this section required multiple prints (at least one print per color) and are the culmination of anywhere from several days to more than a week.

PROOF OF CONCEPT

Thus far the Studio has used the 3D prototype primarily in support of sales efforts. In the pre-sale efforts the Enclos proposed system design was modeled using a number of tools including CAD, Rhino and 3DMax. A focused segment of the design, such as a stack joint, anchor condition or fitting is isolated and modeled with all components including bolts and gaskets. This 3D study is then exported from its solid geometry into a .STL file format which the printer software can interpret. The printer is able to print multiple components at one time, but must be of the same color. The



Figure 1: Jacob Javits Convention Center - typical node assembly.

plastic material is placed by the machine one thin layer at a time gradually replicating the original geometry. The precision of the end product is 0.0010".

The physical models allow everyone on the design team to review concepts. In sales presentations the 3D prints have received an encouraging response, luring drifters back into the design conversation and providing a full-scale physical diagram in support of our technical proposal drawings. The physical model is a platform of engagement and collaboration.

DESIGN ASSEMBLIES

Printing the models out of the tough and durable ABS plastic allows the prototypes to act as working parts. This enables the design team to test form, fit and function shortly after conceiving the design. The ABS models can be drilled, tapped, sanded and painted to achieve appearances beyond the available colors. The Studio has appended the plastic models with real components from Enclos fabrication shops to represent fasteners, gaskets and thermal breaks. Additionally the 3D prints have been used to create plastic chicken-head sections to be used in thermal testing research projects.

The ability to test tolerances on part assemblies before fabrication is a valuable asset to the project workflow. A prototype of the stainless steel cable fitting on the

500 Fifth Avenue atrium wall revealed an opportunity to improve the fit between the glass capturing patch clamp and the cast fitting armature. Being able to predict such issues early allow the project team to make adjustments in advance and in the field ensuring a higher quality product.

SHAPE APPROVAL

There are many applications for 3D prototypes at each stage of the project delivery workflow. An obvious potential is to use the prototype for profile approval with the architect. Other examples include using the prototype to diagram fabrication sequences with shop crews, explain installation strategies in the field, and to verify tolerances.

CONCLUSION

Integrating 3D rapid prototyping into the design and sales efforts has been extremely successful to date. The machine often runs non-stop in times of intense sales efforts. Full-scale mock-ups were a key selling point on projects such as Mesa College, and continue to aid design collaboration internally, and sales communication externally, on the unique features of current projects. Current investigations within the Studio include exploring potential representations at macro-scales such as full-building sites and complex geometries.

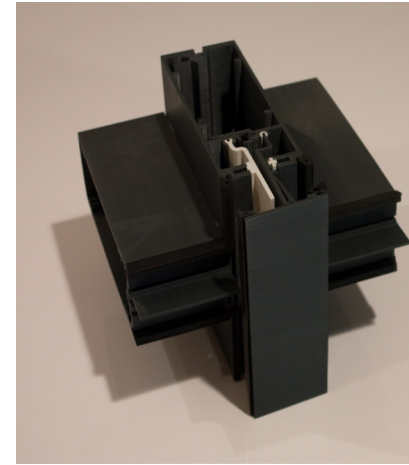


Figure 2: Mesa College typical assembly.



Figure 3: 500 Fifth Avenue Atrium Wall cable fitting prototype.



Figure 4: Nashville Music City Center facade system with aluminum cassettes (front) attached to aluminum frame, braced back to horizontal steel truss (black) suspended by vertical rods.