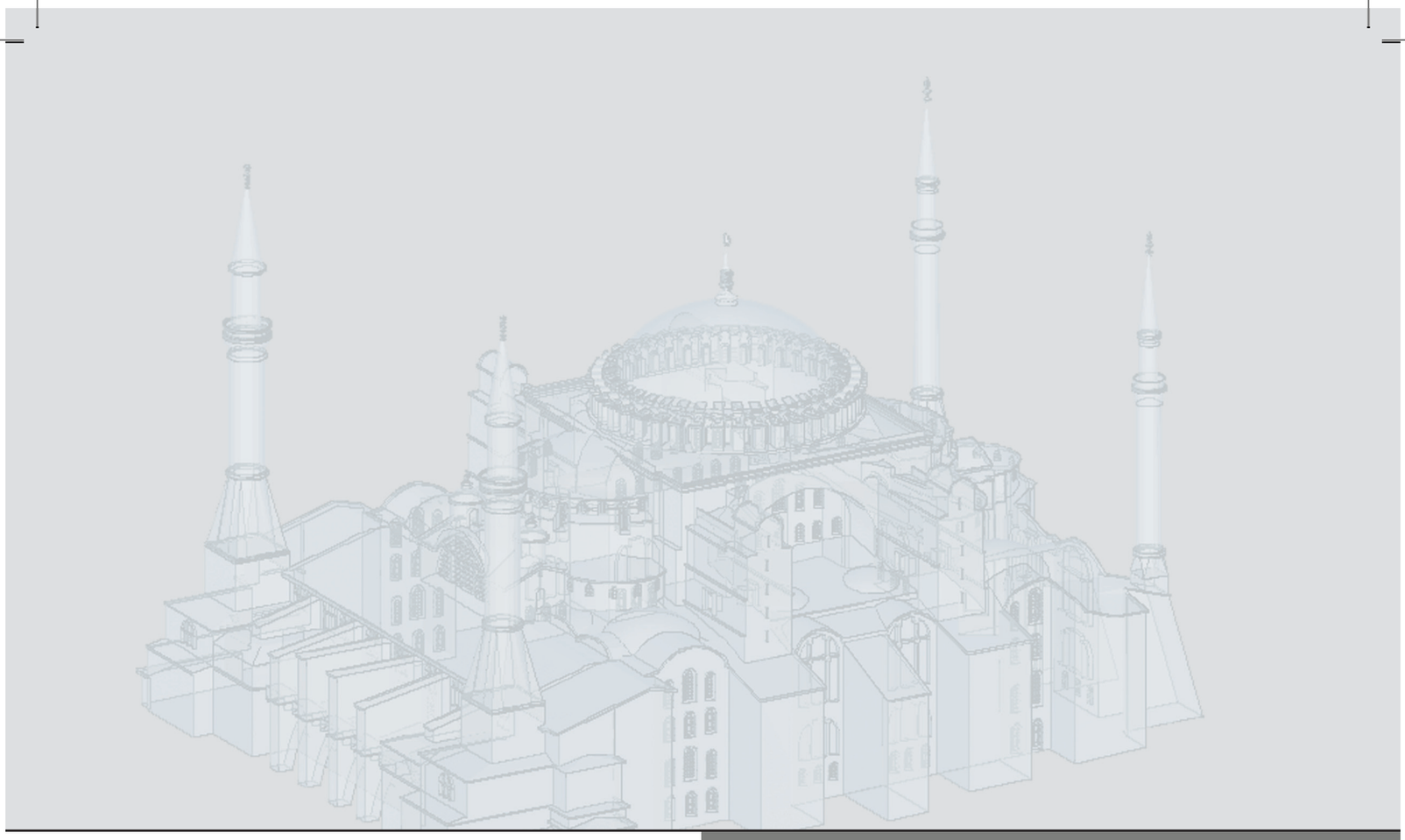

Architectural Design

OBJET

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1 About This Applications Guide

Using This Applications Guide

This applications guide provides instructions for designing and planning architectural models, creating architectural STL files and preparing and printing architectural files using Objet 3-D printing systems. It explains how to use features and small details and provides practical examples to guide you as you design architectural models.

For More Information

Visit http://www.objet.com/ for more details about Objet's technology and products and for applications information.

Terms Used in This Guide

STL – The file format used for printing 3-D models

Model material – Material used for building models

Support material – Material used for supporting the structure of models during printing

2 Introduction

3-D Printing of Architectural Applications

Printing 3-D architectural models is a distinctive application that comes with a unique set of advantages and limitations that are typical to this niche application. This method will become increasingly popular as people become aware of the great time-savings that it offers in the design phase. The greatest advantage in the printing of 3-D architectural models is that it reduces the number of steps needed to create models, thus minimizing design time, yet it can produce the fine details of a final architectural plan.

Computer simulations have been used in engineering and architecture for a long time. However, visualization of buildings was traditionally done using scale models made of wood or foam board. This allowed architects to see the building in a three-dimensional format so that obvious problems would be revealed and could be rectified. But this method was very cumbersome and time consuming. In comparison, the advantages of Objet's new cutting-edge technology are obvious.

Printing 3-D architectural models using an Objet 3-D printing system requires an understanding of the concepts and processes of architectural design, including notions of scale, proportion, space, form, and structure.

Architectural Software

Objet 3-D printers print three-dimensional models of architectural designs using solid image design tools that are used for 2-D/3-D architectural design in STL format, such as Solid Works®, Pro-E®, Unigraphics®, AutoCAD®, and 3-D Studio MAX/VIZ®.

Although many architects use AutoCAD and 3-D Studio MAX/VIZ for their 2-D/3-D architectural designs, this applications guide will focus on the format specifications and tips for proper design, rather than on the software itself.

Format Specifications

STL is the abbreviation for Standard Triangulation Language. The principle of this file type is simple: every object is formed from a collection of surfaces and each surface can be described as a collection of triangles. For instance, a square can be described as 2 triangles. A cube can be formed from 6 × 2 triangles = 12 triangles. Curved surfaces require more triangles. When the tolerance of the surface is high, i.e. when the surface should be very smooth, more triangles are required, resulting in heavy files. Small STL files will give rougher descriptions.

STL is frequently used in rapid prototyping and most of the CAD systems can export STL files. More and more applications have begun to use STL files. This software is an example of the expansion of the use of STL files which was originally developed for use in RP applications. The tooling module has made it possible to design molds out of the STL description of an object.

The ASCII.STL file must start with the lower case keyword 'solid' and end with 'end-solid'. Between these keywords are listings of individual triangles that define the faces of the solid model. Each individual triangle description defines a single normal vector directed away from the solid's surface followed by the X-Y-Z components for all three of the vertices. These values are in Cartesian coordinates and are floating point values. The triangle values should all be positive and contained within the building volume. For this project the values are 0 to 14 inches in the X vertex, 0 to 10 in the Y, and 0 to 12 in the Z.

Preparation of the External File from CAD

The following is a list of the steps that should be taken in order to prepare the external file for use by the Objet 3-D printer, and subsequently to prepare the selected model for printing. There are slight variations between the different solid image design programs in which external files are prepared. These instructions, however, apply to all programs.

To prepare an external file for use by the Objet 3-D printer:

- On the main menu bar select File > Save As. The Save As dialog box opens.
- In the Type of Files window select the extension (*.STL)
- Select Options and choose from the following:
  Total Quality – default value of approximately 0.01.
  Detail Quality – default value of approximately 4˚.
- The lower the value selected, the more accurate the saved file, although the saved file is correspondingly larger.
- Resulting triangles should not have a Z resolution smaller than of 0.02mm.
- Select an option and press OK.

3 Design of 3-D Architectural Models

Print Size

Computer simulations and 3-D printing of architectural models involve scaling down the original design. As a first step, the required printing size must be determined. In some models, it may be more practical to cut the 3-D file into two or more models in order to fully fit it into the printing envelope. In those cases, it is recommended that the file be cut at the floor level (without the ceiling or roof), where minimum support structures would be used. In addition, the file should not be repaired but set-up only after the scale-down has been performed.

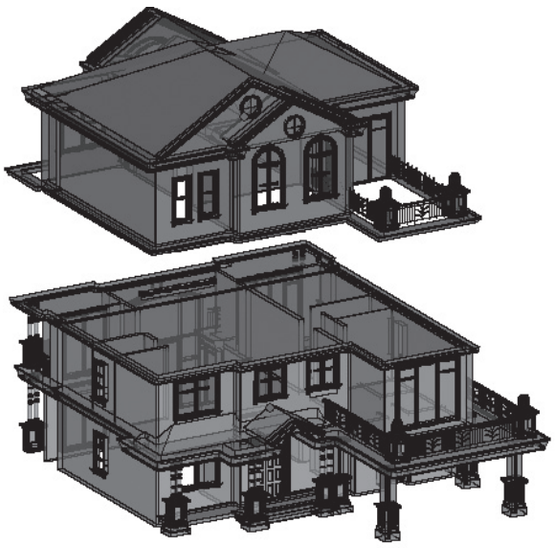

Figure 1: Divided model to fit the full printing envelope

Printing Small Features

A safe, yet dependable value for minimum feature size is in the region of 1.3 mm (0.050 inches) for features that carry no load. For features that have certain load applied, such as walls, window frames, or fences, a minimal feature of 2.6mm (0.1 inches) may be required.

As a general rule, one should aim to scale up all small features to the maximum allowed. Walls and external parts should be scaled to the greatest wall thickness possible.

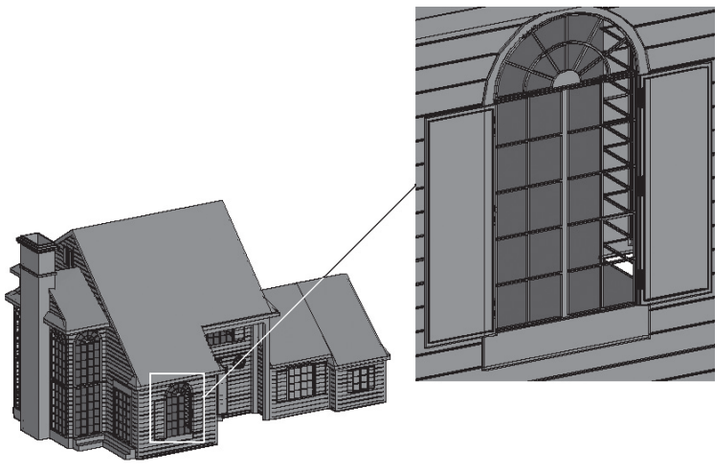

Figure 2: Printing small details

Level of Details

Printing scaled down models requires a scale-down of all the small details as well. The thickness of real house walls may end up being less than 1mm thick, after the scale-down to a factor of 1:1000. Consequently, small details such as windows frames, fences and skylight windows may become almost unnoticeable. Considering this, one should determine in advance the smallest detail that must be included in the printed model. This is an essential step towards achieving satisfactory printing results.

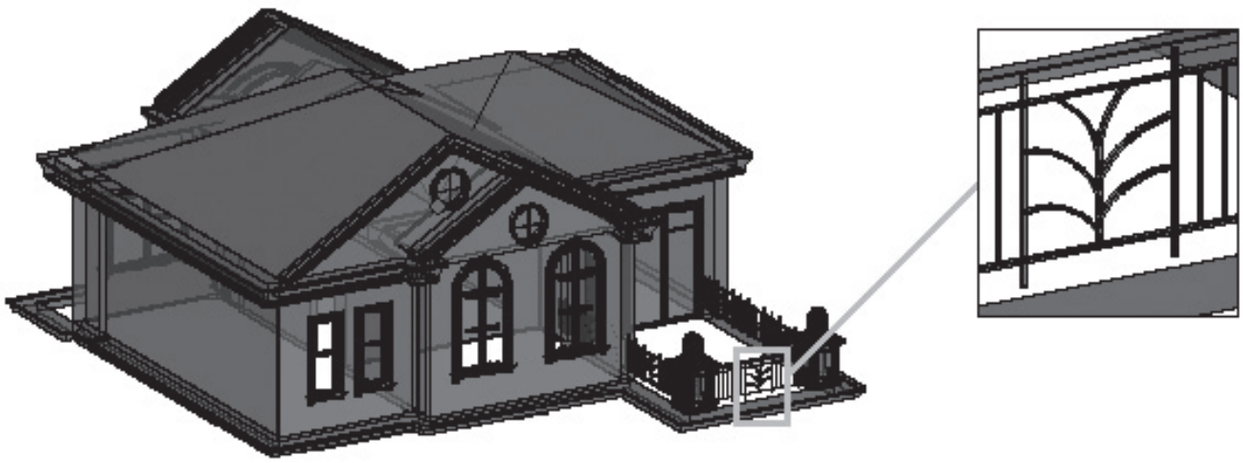

Figure 3: Determining the level of detailing

There are different ways to overcome the small details obstacle. Some design software can recognize small details automatically and thicken or enlarge them to the minimum required printable size. Other software packages require manual manipulation for each selected object. Also, depending on the software, you can define what you consider to be small and the Small Part Filter can remove small parts automatically. You can choose to remove all small parts or to manually remove selected shells.

The Support Structure

One of the major advantages of printing architectural models using Objet's technology is the use of gel-like support structures that are automatically generated during the printing process. The support structure is easily removed using the WaterJet system which keeps small features and fine details intact by utilizing a straightforward and effortless cleaning system.

The printing of 3-D architectural models results in solid models. Such models, illustrated in the figure below, can be turned into a hollow shell with a minimum wall thickness of 4mm. In such a design, the inner core of this architectural model would be filled with support material, reducing model cost and weight (in certain cases, the support structure can be washed away).

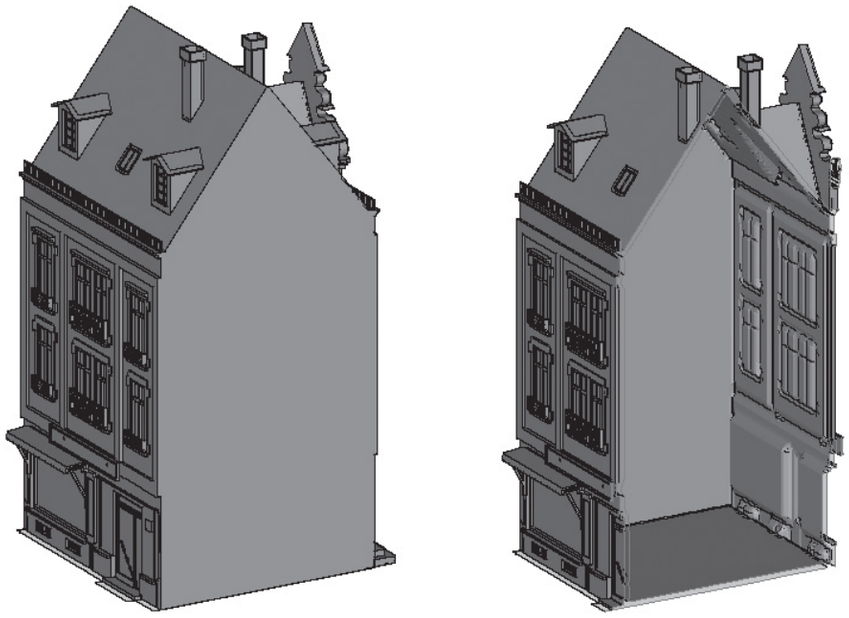

Figure 4: The hollow inside of a 3-D architectural model

Special care must be taken while using the WaterJet to clean the support structure of architectural models. In order to maximize the effectiveness of the cleaning process, the WaterJet unit was designed to include two types of diza elements - the jet diza and the spray diza. Each has its own unique ability to help increase productivity, shorten cleaning time, and meet high quality requirements.

To clean large parts that do not include thin walls or fragile parts, the jet spray is recommended. The jet diza can be used in the same way as a specula to cut and trim large support structure areas and wash them away. The jet diza is also very efficient and effective at cleaning cavities as it clears excess material from holes.

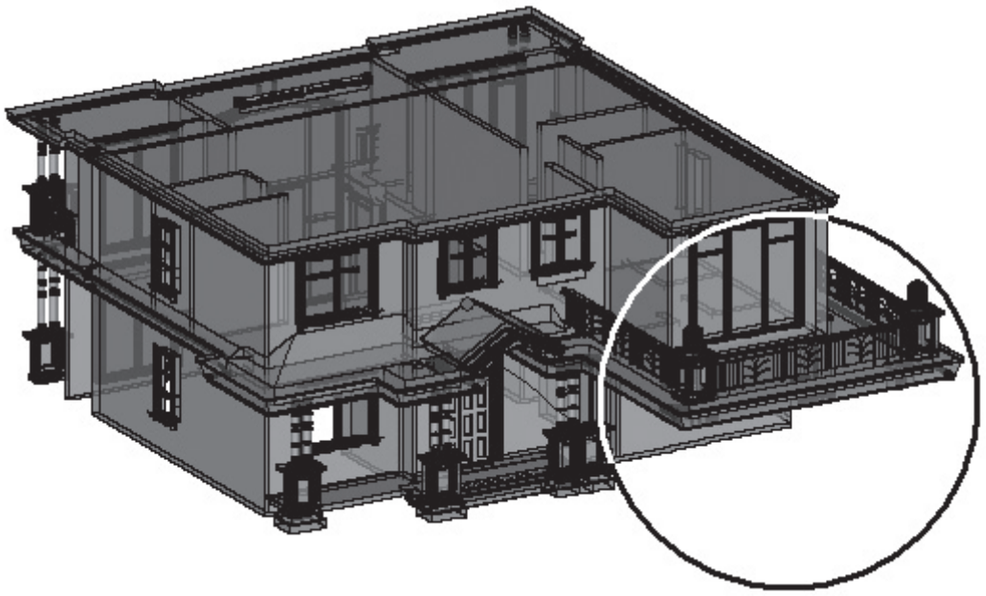

Figure 5: Construction of a long-overhang roof

The spray diza is more suitable for cleaning detailed parts with thin walls or fragile, delicate and breakable sections. Parts that should be cleaned using the spray diza are small details such as window frames, fences and skylight windows.

An additional support structure issue may be involved while building models that include non-supported construction, such as an extended roof overhang covering the entrance to a building (see figure 5, above). Once printing is completed and the architectural model is cleaned, such a roof could bend under its own weight. This bending can be prevented by printing a supporting part to hold and restrain the overhang.