

# Conceptual Design Modeling in Autodesk Revit Architecture 2010

In building design, visualizing a form in the earliest stages enhances a designer's ability to communicate ideas; and the ability to analyze and evaluate these forms yields an advantage in predicting and optimizing the real-world performance of the built project. These attributes form a core value of the building information modeling (BIM) process, for which Autodesk® Revit® Architecture software is purpose-built to support.

With the release of Revit Architecture 2010, users now have access to a robust collection of easy-to-use modeling tools for quick and precise design conceptualization, visualization, and communication. This release supports several new modeling paradigms, including intuitive direct manipulation, robust freeform modeling, and bidirectional parametric control. In addition, some highly specialized patterning and panelization techniques are now more readily accessible for users of all skill levels.

Using a speculative urban high-rise project as the model for exploration, this white paper details how CASE Design, a design technology consultancy based in New York City, utilized the new conceptual design tools in Revit Architecture to more easily create massing designs; explore design alternatives based on qualitative and quantitative feedback; and address various environmental, constructability, and aesthetic concerns that arose during project realization.

In order to clearly address the new Parametric Massing Design and Custom Panelization modeling environments introduced with this release, this white paper has been divided into two sections. In the Parametric Massing Design section, the steps taken to explore massing design alternatives informed by qualitative and quantitative feedback are described. In the Custom Panelization section, the mass design options generated in the first section are used as the basis for informed panelization studies.



## Contents

<b>1. Parametric Massing Design: The Challenge of the Building Form .....</b>	<b>3</b>
1.1 Site and Context Requirements .....	3
1.2 Programmatic and Planning Requirements .....	4
1.3 Environmental Requirements.....	4
<b>2. Massing Approach: Creating the Building Form .....</b>	<b>4</b>
2.1 Maximizing Buildable Volume .....	4
2.2 Responding Intuitively to Urban Context.....	5
2.3 Increasing Project Precision .....	5
2.4 Minimizing the Impact of Shadows .....	6
2.5 Maximizing Solar Collection.....	7
2.6 Exploring Design Alternatives .....	8
<b>3. Custom Panelization: Creating the Custom Panel .....</b>	<b>8</b>
3.1 Defining the Pattern .....	9
<b>4. Designing the Panel: Panel-Based Solar Shading .....</b>	<b>9</b>
4.1 Customizing the Rhomboid Panel.....	10
4.2 Customizing the Hexagon Panel.....	10
4.3 Populating the Panels onto the Building Form.....	11
4.4 Using Quantitative Data to Inform Final Design Decisions .....	11
<b>5. Conclusion.....</b>	<b>12</b>
<b>6. About the Authors.....</b>	<b>12</b>

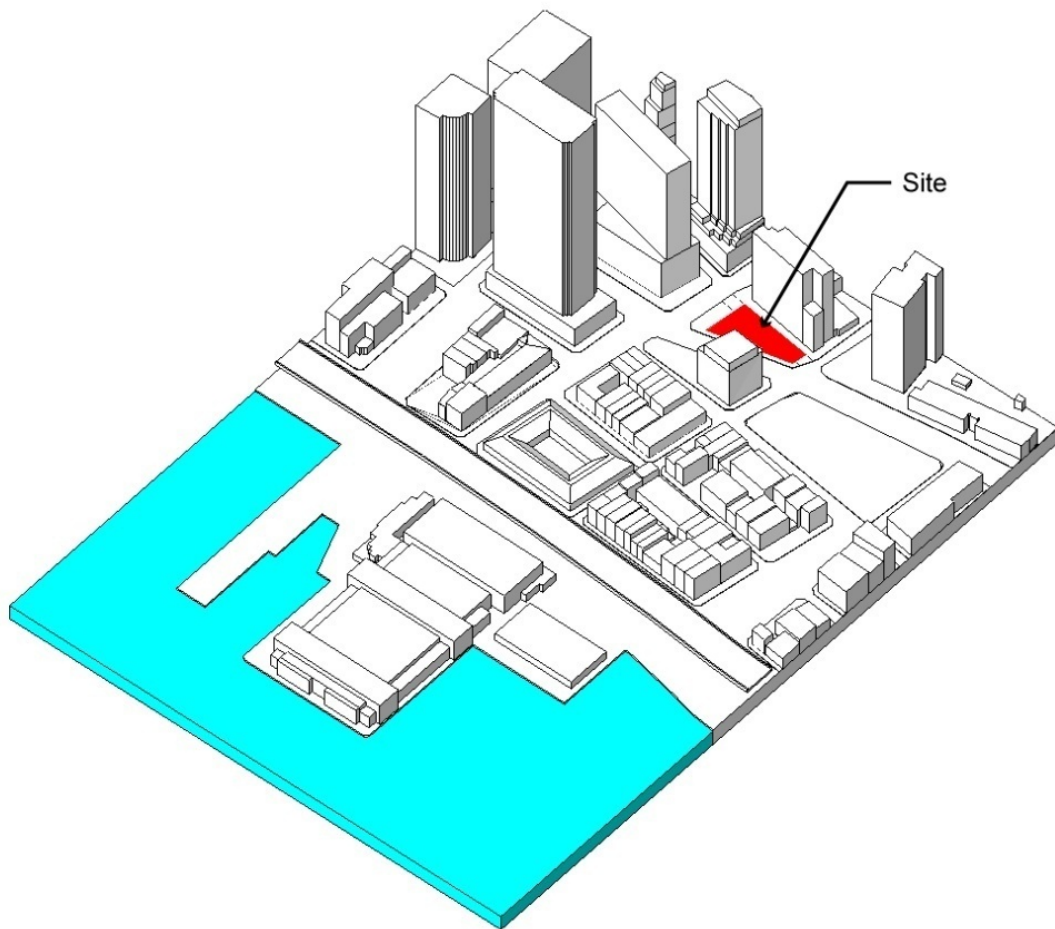
## 1. Parametric Massing Design: The Challenge of the Building Form

While approach and attitude about design may differ from firm to firm, most designers would agree that iterative design can lead to more optimal solutions. However, several concerns arise, such as: How does a designer find the right solution for any given project? How can design criteria be used more effectively to evaluate possible design solutions? And finally, how can technology help make this exploration and discovery process more informative and more efficient?

With regard to the specific project explored in this white paper, several key constraints affected the outcome of the design.

### 1.1 Site and Context Requirements

The site for the tower is located on the edge of a high-rise business district, adjacent to a low-rise residential district near a waterfront. The site is an undeveloped triangular parcel bordered by two major streets. An existing secondary street to the north of the site will be closed and incorporated into the buildable footprint of the parcel.



### 1.2 Programmatic and Planning Requirements

The program of the tower will be a mixture of hotel (7,000 square meters) and residential (19,000 square meters) space, with the hotel occupying the lower section of the building. The unusual shape and context of the site present challenging planning requirements. The design must meet the stated programmatic requirements within a tight footprint of 951 square meters, while not exceeding 150 meters in height. Furthermore, the design should minimize the impact of overshadowing on the adjacent buildings and streets.

### 1.3 Environmental Requirements

Complicating things further is a requirement calling for a building form that is designed for solar collection. With this added requirement for energy reduction, the exterior shell of the form will utilize special photovoltaic panels to make best use of the solar energy available to the site, which will translate to lower operating costs.

## 2. Massing Approach: Creating the Building Form

The new Conceptual Mass environment supports both surface and solid modeling workflows. The solid modeling workflow maintains the benefits of working with mass families, such as the use of the Building Maker tools, while also providing new direct manipulation tools that significantly enhance the ability to create faster, iterative design models.

With these new tools, surfaces can now be created and manipulated, or they can be thickened to create solid masses. Both surfaces and the solid faces also now serve as the basis for the new custom panel families. This white paper focuses primarily on the solid modeling workflow—the most appropriate technique for a volumetric design—and demonstrates how these masses can be incorporated into a Revit Architecture project.

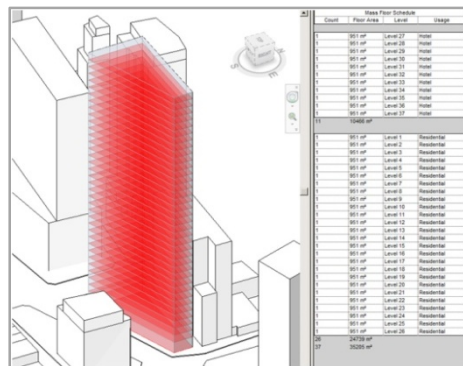
### 2.1 Maximizing Buildable Volume

To visualize the extents of the maximum buildable volume, the full parcel is extruded to the maximum height (150 meters) using the Create Form button, a new context aware geometry creation feature that replaces individual modeling commands such as Extrusion, Sweep, and Blend.

This conceptual mass family is placed into a Revit Architecture project containing the site and surrounding context. Levels are then used to create mass floors from the maximum buildable volume, and a mass floor schedule is generated showing a total buildable area of 35,205 square meters.



**Conceptual Mass in the Project Environment**



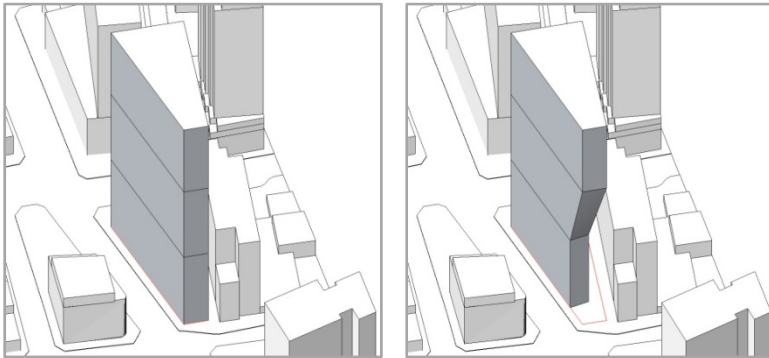
## CONCEPTUAL DESIGN MODELING IN AUTODESK REVIT ARCHITECTURE 2010

Although these results might be ideal for the developer, they leave much to be desired from both urban and aesthetic perspectives. In addition, city planning officials would likely have concerns. However, by utilizing the new conceptual mass tools in Revit Architecture, these issues can be more readily addressed.

### 2.2 Responding Intuitively to Urban Context

For the tower to respond to its urban context, the programmatic volume requires fundamental modifications to create better public space at the street level.

To address this, the north face of the conceptual mass is split using the Add Profile and Add Edge tools, allowing for a more generous pedestrian walkway and providing better light and air to the adjacent building to the north.

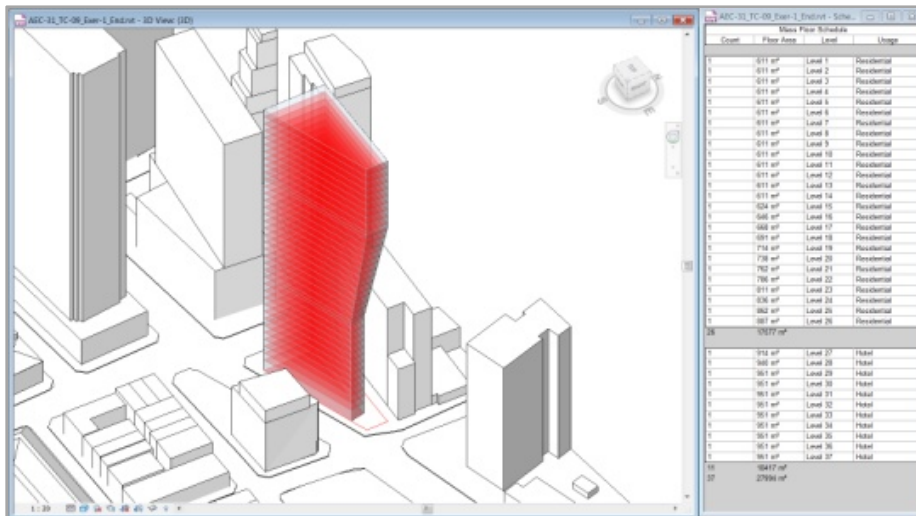


Performing this action allows the design team to manipulate the conceptual mass in a variety of ways. In this situation, the lower section of the mass is moved away from the adjacent building. As a result of moving the east face of the conceptual mass, an entrance plaza and public space adjacent to the low-rise residential district can be created. With the quick edits in place, potential city planning concerns have been addressed.

### 2.3 Increasing Project Precision

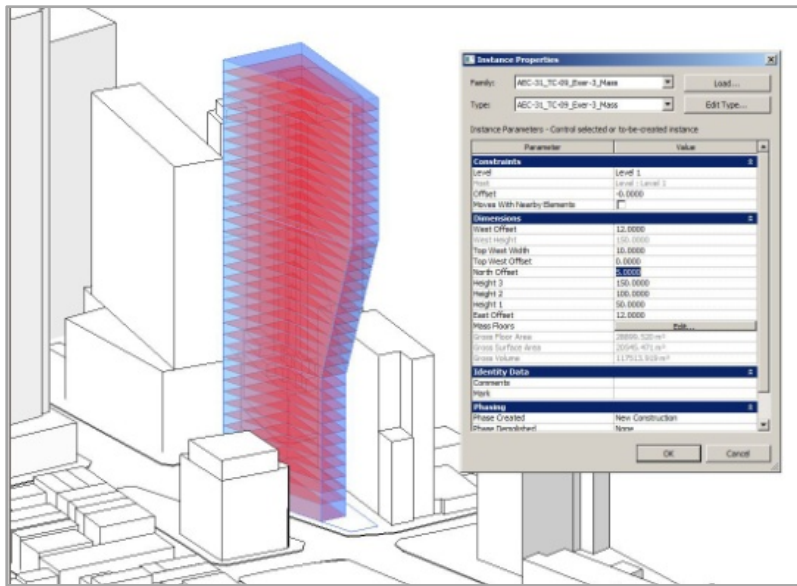
In order to understand the impact that design modifications have on the programmatic requirements, the conceptual mass is updated in the Revit Architecture project.

Accordingly, the mass floors and corresponding area schedule in Revit Architecture are both automatically updated to reflect changes.



With modifications in place, the current conceptual mass is now 1,990 square meters over the program target. Up until this point, design modifications have been made graphically via direct manipulation techniques. In order to better control the precision of future modifications, reference planes and parameters are now added, enabling increased degrees of control through numeric input.

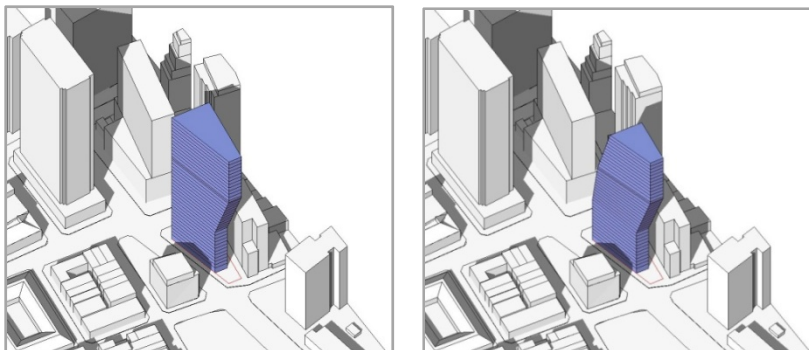
With the introduction of bidirectional parameters, the model is modified using both numerical and graphical means. Changes made using the direct manipulation tools will now conversely update the numerical parameters in the model. The introduction of parameters also provides the flexibility to make changes directly from within the project environment, giving the design team instant feedback from area schedules.



The tower design now satisfies the requirements of both the client and city planners; however, additional steps should still be taken to further refine the building form and environmental impact.

## 2.4 Minimizing the Impact of Shadows

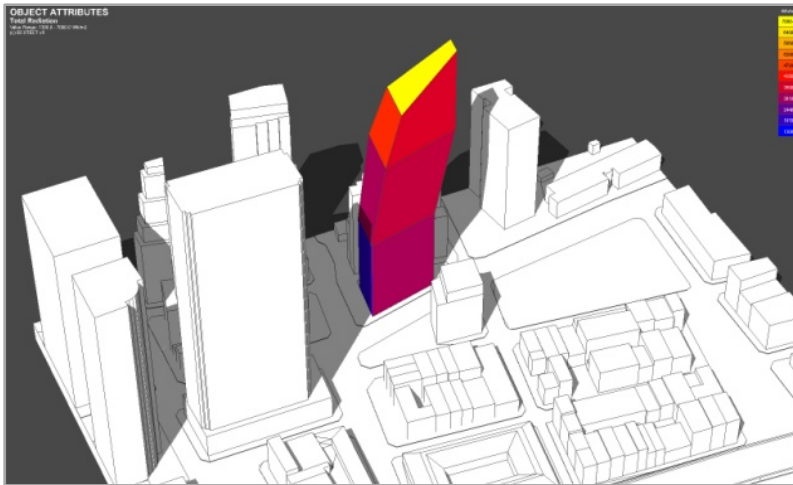
Reducing the overshadowing of the tower on neighboring buildings and streets becomes the primary concern at this stage of the design process. By enabling the interactive shadow tools within Revit Architecture, the design team can quickly identify troublesome areas. To address these areas, the west face of the conceptual mass is altered to reduce the impact of shadows on the existing towers to the west of the site. With this simple action, the project team reduces the effects of overshadowing, sculpts the top of the tower, and verifies that modifications meet program targets.



## 2.5 Maximizing Solar Collection

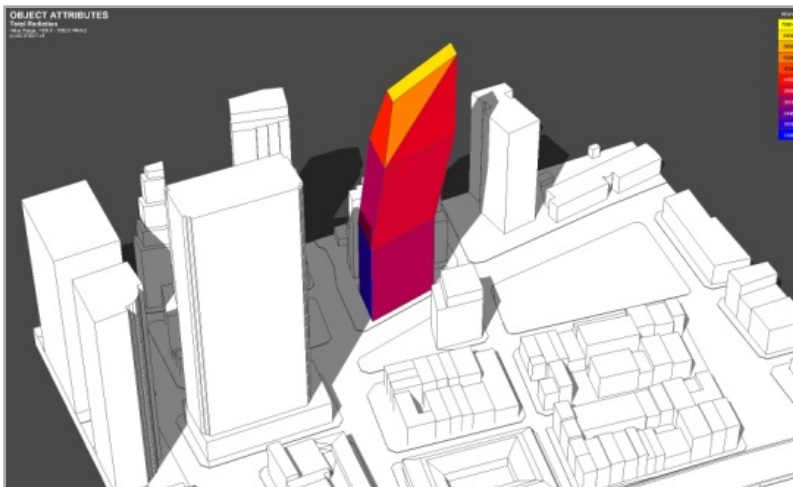
With the building form beginning to take shape according to programmatic and site requirements, consideration is now given to designing for solar collection.

Autodesk® Ecotect™ Analysis 2010 software, an interactive early stage building performance simulation tool, is used for solar insolation analysis. After importing the building form into Ecotect Analysis, tests reveal that the buildings to the west cast shadows across the western face of the tower, while the southern face, particularly near the top, is largely unobstructed.



Based on the information provided by Ecotect Analysis, the southern face is further refined in Revit Architecture. Using the Add Edge tool, an edge is added to the south face, creating a top vertex that is then modified via direct manipulation. The result is a decreased angle of incidence to the sun.

Performing a second insolation analysis of the updated building form with Ecotect Analysis reveals an increase in solar radiation, indicating that the surface is now positioned to maximize photovoltaic panel solar collection.

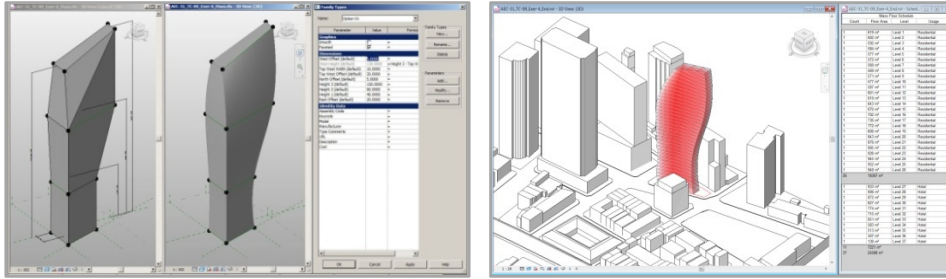


With the preliminary project requirements now met, the team is ready to begin an exploration of alternative designs that will also meet the design criteria.

## 2.6 Exploring Design Alternatives

Using the completed mass as an underlay, additional design options are more readily explored. For this purpose, a series of profiles are created using “associative” 3D snapping, constraining sketches to the base mass, while a curvilinear tower is lofted through these profiles.

The design is then modified by changing parameters, with revisions automatically reflected in both mass options. With the mass family updated and loaded into the Revit Architecture project, switching between mass types can be performed more quickly and seen together within the updated area schedule.



**Parameter-Driven Design Options**

**Curvilinear Tower Option**

The second curvilinear mass adds additional floor area, but also reduces the overall height of the building form. The result is a new building form that still meets area targets, but also slightly reduces the shadows it creates on neighboring buildings.

Equipped with two strong design options to develop, the project team can proceed to envelope design and panelization.

## 3. Custom Panelization: Creating the Custom Panel

In addition to the new Conceptual Mass environment, Revit Architecture now provides an environment for the creation of custom panel families and tools to automate their population onto the surfaces of mass forms. The result is a simplification of a once complex technique, now making it more readily accessible to all building designers. When creating Panel Design there are three key requirements for the design of custom panels.

### **Solar Shading**

The envelope panelization should vary in density and depth based on orientation and adjacent buildings, providing solar shading that will minimize heat gain due to direct solar radiation.

### **Cost and Constructability**

The designer should use precise material takeoffs and surface area calculations to assist in determining the feasibility of different panelization designs. Additionally, with respect to the construction process, a decision should be made as to whether off-site or on-site fabrication is the more cost-effective and appropriate solution.

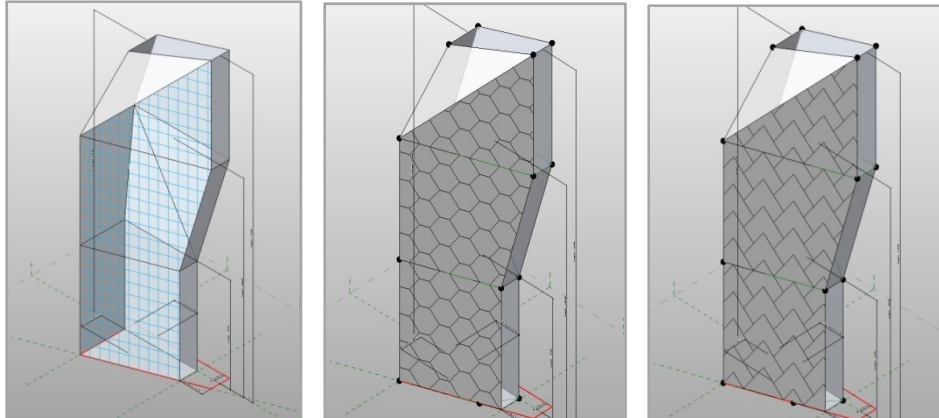
### **Aesthetics**

The panel pattern should be iteratively studied and aesthetically related to the geometry of the mass, ultimately contributing to the iconic qualities of the tower design.



### 3.1 Defining the Pattern

In order to quickly test different paneling options, the Divide Surface tool is used on the faces of conceptual masses. Initially, the isocurves (UV) of the surfaces are displayed based on either the number or spacing specified in the options bar.



**Divided Surface**

**Hex Surface Pattern**

**Arrow Surface Pattern**

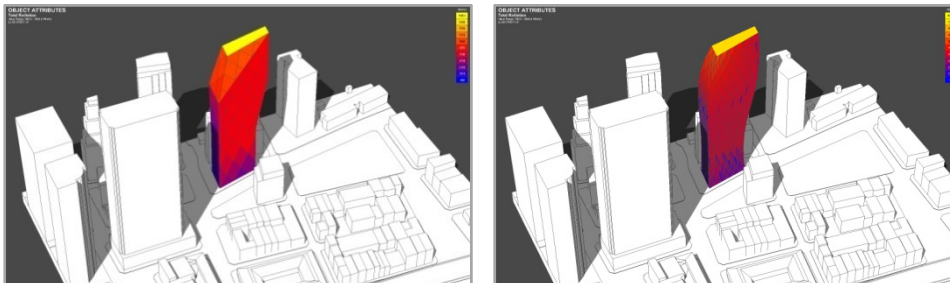
These curves and their intersections form the basis of various predefined patterning options selected from the Change Element Type drop-down list.

Visibility of these patterns is toggled using the Pattern Visibility button. Spacing, rotation, and justification of the pattern are easily controlled by directly interacting with the model and receiving instant visual feedback.

These patterns become the basis of user-defined panels created in the new custom panel family environment. After evaluating several options on each mass, the rhomboid and hexagonal patterns are selected for their respective aesthetic associations with the faceted and curvilinear masses respectively.

## 4. Designing the Panel: Panel-Based Solar Shading

The patterns are now used to understand the potential effects of orientation and solar radiation on the panels. By exporting this model to Ecotect Analysis and running a solar insolation analysis, the project team is able to determine which faces are receiving the most direct solar radiation and the resulting amount of shading required.

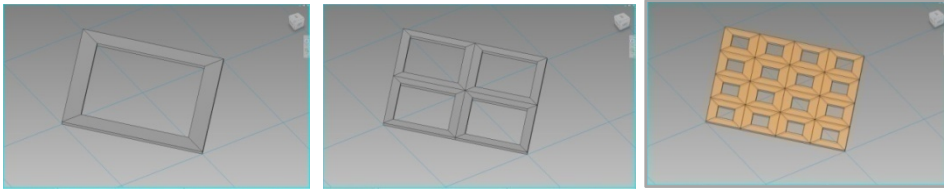


The information resulting from this analysis will become useful in determining the panelization approach and the panel configuration on each mass by informing the shape of the frame and density of the panels.

Here, the advantages of BIM become readily apparent as the delicate balance of building form and performance become more readily determined, met, and maintained.

#### 4.1 Customizing the Rhomboid Panel

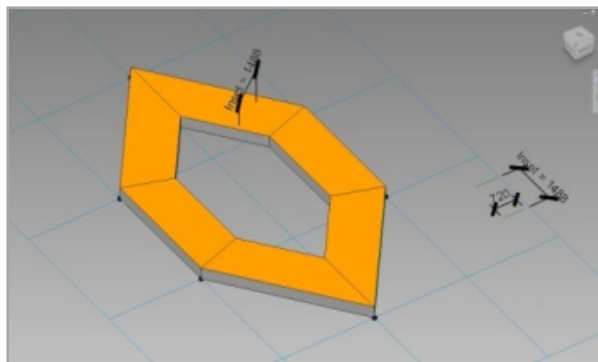
Within the new custom panel family environment, a rhomboid pattern is used as the basis for a new panel family. The width and depth of the frame are controlled using interactive dimensional parameters. In order to vary the density of the panels, the project team mimics a process of recursion, where the first panel is divided into four, and then subsequently each of these panels are further subdivided into four additional panels. Using visibility parameters, different types are created within the panel family. This allows the project team to vary the density of the panel based on solar shading and collection, as well as constructability and aesthetic considerations.



Finally, the faces of the frame are painted, which allows material takeoffs to be extracted from the project once panels are applied.

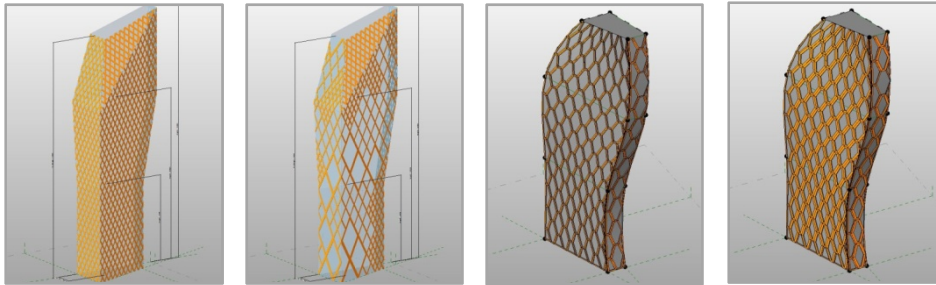
#### 4.2 Customizing the Hexagon Panel

Another custom panel family is created for the curvilinear mass using the Hexagon pattern. Rather than controlling the frame width by changing a dimensional parameter, a graphical control rig is created by using offset reference planes that drive a named parameter. Like the rhomboid panel, materials are painted on the frame, making it possible to schedule surface area after the panels have been populated.



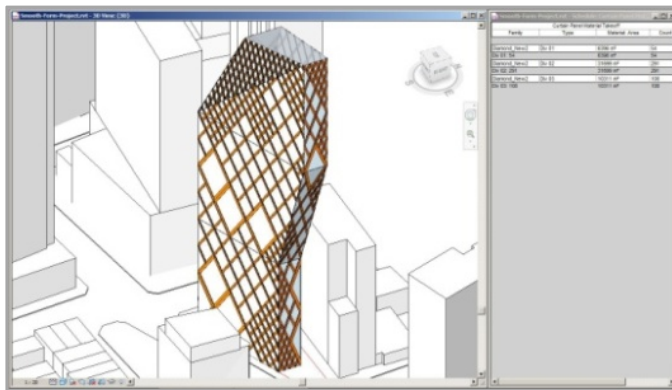
### 4.3 Populating the Panels onto the Building Form

With two panel families created and loaded into the conceptual mass model, new panel types are chosen from the Change Element Type drop-down list, making it possible to apply panels to each face of the mass. Individual modifications are then made to the panels based on existing solar performance and aesthetic requirements. This is done by selecting the appropriate panels and switching between the different types that were created within the panel family. In accordance with the panel requirements, denser panels are used in areas of greater solar exposure.

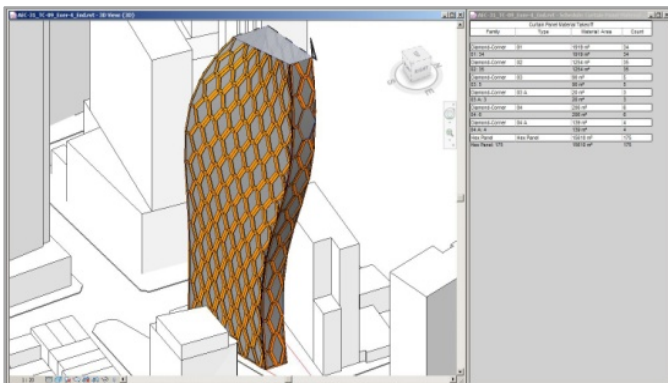


### 4.4 Using Quantitative Data to Inform Final Design Decisions

Now that the panelization approach for each mass has been determined, scheduling tools are used from within the Revit Architecture project to quickly calculate the number of panels and the surface area of each material used.



Since the underlying masses are controlled parametrically, the project team can continue to update and refine the design based on this information, incorporating real-time feedback and modifications, until it is finally concluded that the preliminary design with the custom rhomboid panel patterning is the most optimal design solution for project requirements.





## 5. Conclusion

This white paper and speculative project have demonstrated some of the potential uses of the new conceptual design tools available in Autodesk Revit Architecture 2010 software. The enhanced intuitive design environment helps give designers a notable advantage through the pairing of robust parametric modeling tools for earlier concept development with an already comprehensive and mature BIM platform. The result is a natural extension of the Revit Architecture design environment into a highly capable conceptual design solution for sophisticated form exploration, custom patterning, and panelization.

## 6. About the Authors

### **CASE Design, Inc.**

CASE is a design technology consultancy based in New York City. CASE provides strategic advising to architecture, engineering, and construction firms seeking to transform their practices through technological innovation. We help our clients identify and implement technologies that enable more effective coordination, communication, collaboration, and information exchange. For more information, visit us online at [www.case-inc.com](http://www.case-inc.com).

Autodesk, Autodesk Revit Architecture and Autodesk Ecotect Analysis are registered trademarks or trademarks of Autodesk, Inc., and/or its subsidiaries and/or affiliates in the USA and/or other countries. All other brand names, product names, or trademarks belong to their respective holders. Autodesk reserves the right to alter product offerings and specifications at any time without notice, and is not responsible for typographical or graphical errors that may appear in this document.