

Software for Building Conceptual Design & Modeling

This white paper details how Autodesk tools such as Autodesk Maya, Autodesk 3ds Max, Autodesk Impression and Revit Architecture support conceptual design and the building information modeling process.

While approach and attitude about design may differ from designer to designer, most designers agree that optimal design solutions exist - they just need to be found. The question is, how does a designer find the right solution for any given project? How can design criteria be used more efficiently to evaluate possible design solutions? And how can technology help make this exploration and discovery process more informative and more efficient?

Conceptual building design tools facilitate a designer's exploration of ideas and form. Beyond that, these tools help us find those options that closely align with and address the needs and aspirations of clients - eliminating the irrelevant possibilities while making visible more optimal scenarios deserving of further exploration.

The ability to visualize form in the earliest stages enhances our ability to communicate design ideas; and the ability to analyze and evaluate these forms in their earliest stages yields a major advantage in predicting and optimizing the real world performance of the built project. These attributes form a core value of the building information modeling process, benefiting the participants in this process from the earliest design stages through documentation and construction.

Conceptual Building Design and Computation

One of the most important roles for the architect is to understand their client's design requirements and accurately crystallize those requirements in a conceptual design.

Conceptual design is the process of identifying and visualizing form-finding options based on an initial set of design criteria. Approaches to conceptual design vary widely, from hand sketches done on paper to advanced computer applications that help the designer to interact fluidly and dynamically with their design concept.

Regardless of the approach, successful conceptual design hinges on the ability to:

- Extend form-finding to deliver more meaningful, timely design feedback, often by using algorithms and expressions to more efficiently explore design iterations.
- Drive creativity and understanding by enabling a variety of analyses of a conceptual design - for example a solar study or a heating and cooling analysis of a very early conceptual design.
- Gain a clear understanding of potential, practical, and therefore possible, design solutions much faster and much earlier on in the process.
- Capture early design thinking as part of the building information modeling process to better support design, production, and even construction and fabrication.

Conceptual building design is an iterative process driven by design criteria, client aspirations, and project requirements. The process often brings together a rich array of design disciplines to collectively negotiate high-level design decisions - informed by experience, judgment and enhanced by computational design tools.

Autodesk Tools for Conceptual Design

Autodesk has a variety of tools that can be used for conceptual design, allowing schematic project information to flow among disciplines and project phases, and to inform early design decision making. These toolsets enable designers to generate, visualize and then develop forms into architectural design elements. Through the command of geometry and visualization, project knowledge can be freely shared, and team efforts easily captured, as designers seek solutions that address issues of space and time, form and function, aesthetics and context.

- **Autodesk Maya** software enables a sophisticated, flexible, and open environment for imagining and executing the most complex form-finding exercises. With its roots in the film and gaming industry, and now prominent among the architecture avant-garde, Autodesk Maya offers optimal creative control over complex form, supporting the creation of unique architectural forms during early stage design exploration; forms that are often more robust and less expected than those created with software packages specifically built for architectural design.
- **Revit Architecture** software extends conceptual design information beyond the conceptual design stage. Purpose-built for building information modeling, Revit Architecture provides the ability to quickly define abstract architectural concepts and then accurately transform those ideas (or the forms from disparate models, such as those coming from Autodesk Maya or other generic modeling tools) into rationalized architectural ideas comprised of constructible building components. Revit Architecture is based on the use of coordinated, consistent and computable information about a project - information which can be used throughout the building design process; from early conceptual design stages, as well as during production documentation phases, construction and even building lifecycle management.
- **Autodesk 3ds Max** software is a leading design visualization and form-finding tool that enables architects and designers to accurately convey rich design ideas in their three dimensional, fully rendered contexts. Supporting more granular control over light, material and texture, designers and artists use 3ds Max to

freely express design scenarios helping owners to better understand their proposals.

- **Autodesk Impression** software provides tools for creating evocative presentation graphics with a hand drawn look from existing CAD files. Unlike traditional CAD drawings, which can be dry and technical, Impression presentation drawings speak in a language that both colleagues and clients understand. From loose pencil sketches to watercolor conceptual diagrams, Impression enables the rapid development of high quality images which can facilitate productive and meaningful design review sessions.

Means of Expression

In the book *Tools of the Imagination*¹, Editor Susan Piedmont-Palladino discusses the role that drawing tools and technologies have played in helping to shape architectural form from the Eighteenth Century to Present. She suggests, “Whether a simple pencil or computer software, these tools give form to the wishes and the instructions of the architect, but they are also active shapers of what is possible.”

Design tools not only embody a specific way of working but also offer a framework within which ideas and possibilities exist. Computational design tools make possible more accurate, timelier design iterations - freeing designers of labor constraints that once hindered a more rigorous, more comprehensive analysis and understanding.

Within a building design context, there is a broad range of digital tools that facilitate conceptual design - tools for direct modeling, for performative design, tools that can be used to facilitate digital fabrication, etc. They all provide designers a means of expression; a means of exploring design ideas and assessing their potential.

Direct Modeling

Traditionally, the use of digital tools in architectural design focused on the creation of building models as a means of increasing the efficiency of the documentation process. Like their manufacturing peers, architects are now using modeling tools for design exploration and experimentation, even in the very early stages of design (as well as for digital fabrication techniques at the other end of the product development process).

Sometimes conceptual building models are developed using building-specific modeling software such as **Revit Architecture**. Within Revit Architecture, the Revit Building Maker and Massing Tools collectively offer conceptual design functionality that allows designers to develop conceptual models independently and map them directly to building model components as the design progresses. Forms can be joined together or subtracted to create complex building geometry. Material properties can be associated with masses, which are then used during rendering. Architects can quickly iterate through design studies and create compelling renderings of their conceptual design. Even at this early stage, the designer can validate design features by slicing the model into floors and calculating gross floor areas and overall building volumes.

Alternatively, existing conceptual design studies from other 3D modeling software can be leveraged by importing ACIS® solid models into Revit Architecture and using the Revit Building Maker toolset to connect the conceptual and detailed design stages.

¹ Susan Piedmont-Palladino, *Tools of the Imagination*. New York: Princeton Architectural Press, 2007

In other cases, a product like [Autodesk Maya](#) can be used by architects to create organic models that describe architectural forms. In fact, computational tools designed for non-architectural purposes (like Autodesk Maya) are sometimes adopted by designers to intentionally force them to think and work “out-of-the-box”, delivering fresh ideas and forms otherwise more elusive to the more “traditional” architectural tool palette. The fact that the development of Autodesk Maya has been focused outside the building industry - primarily in the film and gaming industry where it’s used for generating and animating characters - gives their designers a totally different palette.

Example: Gage/Clemenceau Architects

Gage/Clemenceau Architects is a New York City-based architecture and design firm with projects covering a broad spectrum of scales; from a large hotel/resort, to residential projects, even furniture and product design. The firm’s core design tools are AutoCAD® and Autodesk Maya software. For their billable projects, they generally use AutoCAD to do perhaps the majority of the design. But they always try to pick one aspect of the job and use Autodesk Maya to make it absolutely unique. By adapting some of the generic modeling features of Autodesk Maya for architectural design, they use its modeling tools and techniques to facilitate their experimentation with complex architectural forms.

Some of the firm’s most original work is done for architectural design competitions. For these projects, Autodesk Maya brings originality to their designs - originality not particularly evident within a CAD system comprised of pre-packaged architectural forms and architectural intentions. For example, Gage/Clemenceau Architects were finalists in a recent competition sponsored by NYC’s Museum of Modern Art (MoMA) to build an installation in the courtyard of the PS1 Contemporary Art Center. Echoing the sway of underwater sea kelp, the design consisted of sixteen modular structures of carbon steel tubing that would curve overhead, covered with a metal mesh that would allow filtered sunlight into the courtyard area. Autodesk Maya was used to model the metal “kelp” and to study how the design was affected by light - natural daylight, artificial multi-colored light projected from the floor up through the “kelp”, and small LEDs arranged throughout the gold-painted canopy.

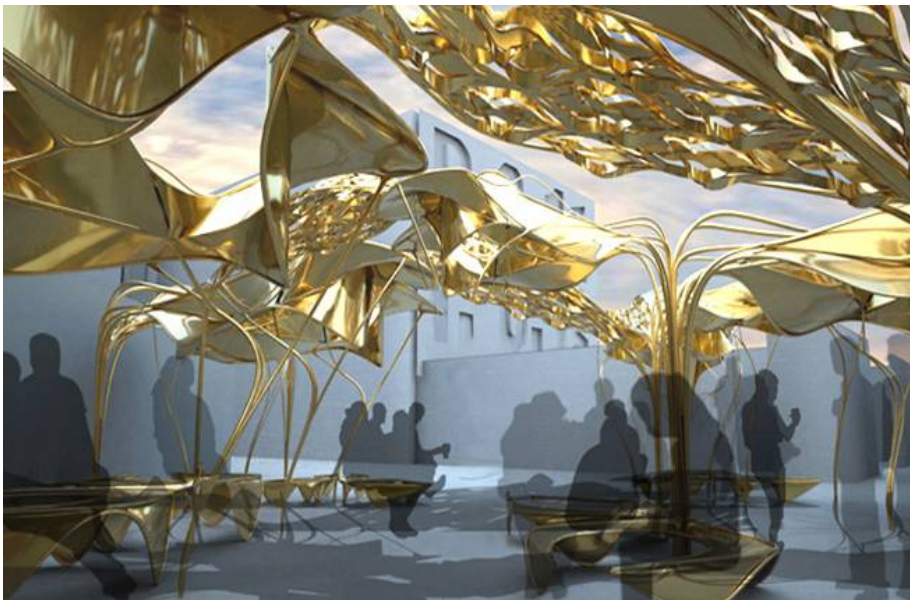


Figure 1:

Gage/Clemenceau Architects use Autodesk Maya to create unique architectural forms, such as this design for a competition sponsored by NYC’s Museum of Modern Art (MoMA).

Performative Design

Performative design is a relatively new field of exploration for conceptual design. Using a performative design methodology, designers can gain a technology advantage by assigning the software application the task of generating form based on scripts, algorithms and mathematical expressions. Scripted routines handle the designer's pre-determined set of design instructions and execute the creation of form based on those instructions.

In addition to offering the advantages of centralized control, scalability and quality assurance, performative design methodologies give designers a means to study more options in a tighter timeframe. By controlling form generation with scripting, increasingly more complex ideas can be studied with greater ease as the computer can scale and regenerate the model appropriately.

Performative design methods release architects from the traditional task of manually constructing models of structures and organizational ideas. Reclaiming valuable time once spent on these tasks, designers are able to spend more time thinking about design. Using scripts, expressions and algorithms to quickly study more complex design ideas, designers can gather higher quality and more timely feedback to better inform the design process.

Parametric components (also referred to as families) offer an open, graphical system within **Revit Architecture** for performative design. Mathematical formulas can be used in families to drive parameters - for example, a formula-driven family can rapidly generate multi-faceted complex curtain wall options for a façade - and the Revit parametric change engine ensures that a change made to a family propagates throughout the entire project. By using formula-based parameters, Revit Architecture can also be used to create very complex, sophisticated forms.

Example: Aedes, Ltd.

Founded in 1982, Aedas one of the largest architectural design consultancies in Hong Kong and currently the fourth largest in the world. Aedas provides expertise in Architecture, Interior Design, Urban Design, Landscape and Graphic Design across a diverse range of market sectors, and is well known for its cutting edge high density mixed commercial designs, master planning, transportation, retail, residential, theme parks and integrated hotel resort projects. Their Ocean Heights One project, located on the Dubai Marina in United Arab Emirates, is a 310-meter tall residential tower. The design evolved to maximize views toward the ocean with a deliberate twist on three of its faces. Revit Architecture was successfully used to design the complex, sculpted geometry of the project. Revit and its parametric change engine allowed Aedas to use algorithmic techniques to employ a traditional flat curtain wall system for the building's curvilinear facade. The use of Revit and a custom Application Programming Interface enabled Aedas to identify the coordinates of every piece of glass on the modularized façade (some 10,000 in total) - verifying that each piece was flat. This ensured the design's constructability and thus the project's economic feasibility.



Figure 2:

Revit Architecture and its parametric change engine enabled Aedas Ltd. to use performative design techniques to create the complex, sculpted geometry for their Ocean Heights One project

Digital Fabrication

For many decades, the manufacturing industry has been creating digital prototypes that are used not only for engineering and analysis, but also for digital fabrication. Architects are now beginning to employ similar strategies and tools on buildings. Digitally controlled fabrication processes such as CNC machining and multi-axis milling, as well as production strategies such as mass-customization have finally entered the lexicon of the building industry.

As such, architects are now creating building models - even very early conceptual designs models - that not only describe form but also suggest potential fabrication techniques. In response, modeling technology must be employed to create digital prototypes that contain sufficient detail and construction information to drive production rather than just a set of drawings and to enable designers to better understand complex geometry and assess constructability.

Example: Gage/Clemenceau Architects

Turning again to Gage/Clemenceau Architects, one of the firm's core design tools is Autodesk Maya, which they also use to front-end their digital fabrication processes.

One of the firm's recent projects was a residential loft where Autodesk Maya was used to design an interior partition that resembled a translucent, frozen drapery. The design pattern of the wall was created in Autodesk Maya using NURBS and fabricated with a CNC (computer numerical control) mill, using the pattern as the toolpath.

On another project, the interior redesign of a modeling agency's headquarters building in NYC, a particularly striking part of the design was an intricate wall surface in the lobby area with a unique wave pattern. Again, the wall was designed in Autodesk Maya and fabricated by using the pattern to create toolpaths for a CNC mill, then milling discreet panels and assembling the wall on site.



Figure 3:

Gage/Clemenceau Architects used Autodesk Maya to design the pattern of this wall, which was then fabricated by using that pattern to create CNC toolpaths.

Forming Your Own Conclusion

Autodesk's offerings for conceptual design are unparalleled in the industry. Central to the conceptual design process is the need for continuous, rich graphic and non-graphic information—coordinated, reliable information delivered through building information modeling for analysis, visualization and documentation. Revit Architecture, Autodesk Maya, Autodesk Impression and Autodesk 3ds Max software products are state-of-the-art conceptual design tools that enrich the creative design process.

Capabilities once available to the select few are now accessible to every designer. From the single family house, to city and regional planning, Autodesk provides the necessary tools used to think about the most complex design problems of our time.

Additional Reading

- Susan C. Piedmont – Palladino, “Tools of the Imagination: Drawing Tools and Technologies from the Eighteenth Century to the Present, 2006.
- Resources at <http://www.autodesk.com/powerofbim>
- “BIM: A Key to Performance-Based Design”
http://images.autodesk.com/adsk/files/bim_a_key_to_performance-based_design.pdf
- Rick Rundell, “BIM and Algorithmic Form Finding”
<http://aec.cadalyst.com/aec/article/articleDetail.jsp?id=402757> and “BIM Concept to Completion” <http://aec.cadalyst.com/aec/article/articleDetail.jsp?id=161073>

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