Chapter 1

Understanding BIM: From the Basics to Advanced Realities

In this chapter we'll cover the principles of a building information modeling (BIM) approach and summarize how BIM differs from a traditional 2D computer-aided design (CAD) process. We'll explain fundamental characteristics of Revit, how Revit delivers the benefits of a true BIM tool, and why Revit is the tool best suited for a process motivated by an integrated and collaborative practice.

In this chapter, you'll learn to:

◆ Identify the advantages of building information modeling

◆ Know what to expect from BIM

Identifying the Advantages of BIM

The production of design documents has traditionally been an exercise in drawing lines to represent a building. These documents become instruction sets: an annotated booklet that describes what the building should look like when complete. The plan, section, elevation, and detail are all skillfully drafted—line by line, drawing by drawing, sheet by sheet. Whether physical or digital, these traditional drawing sets are composed of annotated graphics where each line and text is part of a larger abstraction meant to convey design intent so that a building can eventually be constructed. By and large, this is still the reality we face today, but the process of creating these drawings is being fundamentally changed as a result of BIM.

Let's put this into an historical context for a moment and briefly walk through the evolution of architectural design and documentation.

A Brief History of Design and Documentation

Andrea Palladio's *Four Books on Architecture* (trans. Robert Tavernor and Richard Schofield, MIT Press, 1997) presents an amazing array of drawing techniques that show buildings cut in plan and section and even hybrid drawings that show elevations and sections in one drawing. You can see hints about construction techniques and structural gestures in the form of trusses, arches, and columns.

These representations were meant as simplified expressions of a project, and often they were idealized versions of the building—not necessarily how the building was built. The drawings were communication and documentation tools, themselves works of detailed craftsmanship. In those days (14th–17th centuries), the architect was brought up in the tradition of building and

had integral knowledge of how buildings were constructed. Palladio, like many other architects of his day, grew up as a stonemason. Building techniques were deeply embedded in the construction trades, which in turn spawned the great architects of the time. Other master masons and sculptors who were also architects include the likes of Filippo Brunelleschi, Giovanni Bernini, and Francesco Borromini. These architects are often referred to as the master builders, because they were involved in all facets of the design and construction of buildings.

Over time, however, architecture became more and more academic as building typologies solidified, and under the influence of Beaux Arts tradition, classical reconstructions on paper and in model form became part of the formative education of the architect. The design profession began its gradual separation from the building trades. The notion of design process and iterative problem solving became critical attributes of a design professional—in many cases superseding knowledge of construction means and methods.

With modern architecture, solving abstract spatial problems, accommodating programmatic elements, and experimenting with new materials became driving forces. The machine age and the promise of mass production were idealized and fully embraced. Le Corbusier's (1887–1965) romantic vision of steamships and automobiles inspired a new generation of architecture, and buildings became increasingly machine-like. Consider all the office towers and commercial office parks that have emerged, each with internal mechanical systems to keep them operational.

As buildings continued to grow in complexity, both technically and programmatically, the architect grew more removed from the act of physical construction. Modern materials such as steel and reinforced concrete became prevalent, and complex building systems were introduced. In turn, the production of more detailed drawings became a legal and practical requirement. Structural engineers and mechanical engineers were added to the process, as need for specialized knowledge of building systems grew. No longer could the architect expect to produce a few simple drawings and have a building erected. Complexity in building systems demanded greater amounts of information, and this information was delivered in the form of larger and more complex construction document sets. Architects today find themselves drafting, producing details, working with a wide range of consultants, and still having to create sketches for contractors in the field in order to resolve the complexity of construction assemblies.

The traditional production of plans, sections, and elevations continues to this day, but with far more drawings than in the days of Palladio. At the same time, we ask these questions: Will all these drawings be necessary in the near future? Will the adoption of BIM lead to new ways of communicating the design, new delivery methods, new forms of construction, and new roles for the architect? Can a shift in technology lead to a shift in thinking about the building process?

Building Information Modeling

Fast-forward to the present context and the advent of building information modeling. The production of drawings is now streamlined by creating a digital 3D model composed of virtual building elements. These elements are loaded with data that describe not only geometry, but also material, fire rating, cost, manufacturer, count, and just about any other metadata you can imagine. The focus moves from 2D abstractions to integrated model delivery. It's now possible to detect spatial clashes between the multitudes of complex systems in the building. You can know with confidence whether ductwork will interfere with the structural steel long before construction starts.

The goal of reducing errors and smoothing out the construction process is driving firms to be more efficient, effective, and productive. With BIM, all the plans, sections, and elevations are derivative representations of the model: producing these drawings is no longer a set of isolated, repetitive, and discontinuous tasks. A data-rich model also means that more analysis and iterative searching for optimal solutions can occur early in the design process. As detail is added, the model becomes an increasingly accurate representation of what will actually be built. The model itself can be used to generate parts lists, shop drawings, and instructions for industrially produced elements for the fabrication process. If you can send a digital file that can instruct machines to produce components, the need for traditional annotated drawings might disappear entirely. The ultimate benefits of BIM are still emerging in a market primed to change radically the way buildings are designed and built. A shift in process and expectation is happening in the architecture, engineering, and construction (AEC) world, with private and public sector owners beginning to demand BIM models as part of the delivery package.

The shift from traditional 2D abstractions to on-demand simulations of building performance, usage, and cost is no longer a futuristic fantasy but a reality. In the age of information-rich digital models, all disciplines involved with a project can share a single database. Architecture, structure, mechanical, infrastructure, and construction can be coordinated in ways never before possible.

Models can now be sent directly to fabrication numerically controlled machines (CNC), bypassing the need for traditional shop drawings. Energy analysis can be done at the outset of design, and construction costs are becoming increasingly predictable. These are just a few of the exciting opportunities that a BIM approach offers. Designers and contractors can begin to look at the entire building process—from preliminary design through construction documentation into construction—and rethink how buildings come together. The whole notion of paper-based delivery may become obsolete as more players adopt up-to-date, accurate, digital models.

With the Revit building information model, a parametric 3D model is created that produces traditional building abstractions such as plans, sections, elevations, details, and schedules. The drawings produced aren't discrete collections of manually coordinated lines, but interactive representations or, more accurately, different views of a model. Working in a model-based framework such as Revit guarantees that a change in one view will propagate to all other views of the model. As you shift elements in plan, they simultaneously change in elevation and section. If you change a level height, all the walls and floors associated with that level update automatically and adjust their base/height/length to the new condition. If you remove a door from your model, it's simultaneously removed from all other views, and your door schedule is updated automatically. This unprecedented level of coordination allows designers and builders to better control and display information, ensuring higher quality and a leaner process.

The immediate access to 3D visualization of the building and its spaces makes it much easier to understand and communicate the building design. One model can also contain many variations (Design Options), any of which can be explored at any stage in the design process. Integrated design and documentation keeps the data centralized and coordinated. This in turn leads to live and up-to-date schedules and quantity take-offs. That information can then be used to make decisions early in the design process, reducing risk and cost overruns. Not only that, but with the coordinated BIM model, you can start running energy analysis, solar studies, daylight simulations, and egress analysis much earlier in the process, allowing you to iterate through design decisions earlier, not later.

Coordination with BIM is now required for many buildings to come into existence. BIM is extremely useful for complex projects such as Daniel Libeskind's Denver Art Museum, with its extreme geometric configuration (Figure 1.1). Integrating the mechanical and structural systems into a 3D model is essential to completing a building of this complexity. Exact spatial organization of structural members could be modeled, which in turn led to fewer field errors and fewer requests for information. In addition, parts could be sent directly to fabrication from the model, eliminating the need for 2D drawings entirely.

FIGURE 1.1
BIM makes it possible to build more complex buildings with fewer errors.

Denver Art Museum, Daniel Libeskind

Let's not leave out some of the more pleasurable aspects of BIM that go beyond all the technical, economic, and ecological benefits. With a 3D model, you can expect to see changes in how you interact with your team and your clients and in the way you produce presentations. No longer are you stuck with using 2D drawings or outsourcing to create perspective images. You'll find yourself working with your team in close quarters, sharing a model, and exploring it together. With your clients, you can now take them through the building, in full 3D, from the beginning. The experience of working with and visualizing 3D space can't be overemphasized, and people enjoy it immensely. In the BIM era, 3D experience is the norm, not the exception.

BIM and Process Change

When moving to a BIM work environment, you'll experience a change in process and workflow. Perhaps the most immediate and obvious difference is that a traditional CAD system uses many separate files to document a building, whereas a BIM project typically has only one file. With CAD, all the separate files are created individually and have no intelligent connection between them. Each drawing represents a separate piece of work to be managed and updated throughout the design process. With such an unwieldy process, the possibility of uncoordinated data, and thus errors, is very high. The manual change management enforced by CAD is a tedious and error-prone process that requires diligent project management and lots of red lines. BIM provides a different approach to the problem: rather than many files, you work with one logical file. With BIM, all information is consolidated and networked together for you, and the resulting drawings all relate back to a single underlying database, guaranteeing an internally consistent model.

If you understand the basic premise of an integrated building model, then you'll by now have realized that BIM removes the concept of drawing lines to represent objects. Instead, you build walls, roofs, stairs, and furniture. You model the building and its systems. Figure 1.2 shows a 3D sectional view of a Revit model. You can see that the model incorporates façade elements, floors, roofs, parapets, curtain walls, and materials. All this information is modeled and must be designed as it is to be built. You then add information to the drawings to explain the model in the form of parametric tags and keynotes. Although the end result is still a set of printed lines, you rarely draw these lines. This concept of modeling is so simple, and matches more closely the process of building design that you as an architect are familiar with, that you'll get used to the idea in no time.

FIGURE 1.2
The BIM model keeps you honest and focused on solving the design problems of a model, rather than managing lines.
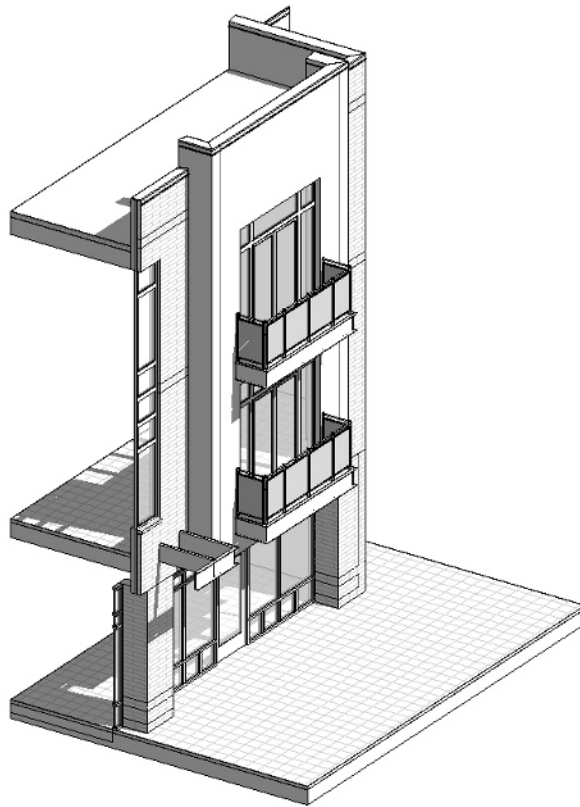

Revit is excellent at managing changes and keeping your model interconnected. Unlike CAD, the intent of BIM is to let the computer take responsibility for redundant interactions and calculations, leaving you, the designer, with more time to design and evaluate your decisions. With a BIM tool such as Revit, be prepared to change your expectations of how to use design software. Remember: you are modeling a building now—not drafting lines. You're doing what you do best: solving complex spatial problems.

Revit Encourages Creativity

Revit's tools are clustered in easy-to-access ribbon tabs that have collections of logically grouped tools. Most of these tools will get you where you need to go with minimal effort. For more complicated conditions, be prepared to put your creativity to use. Remember, Revit is a 3D modeling application that will let you build almost anything you want. For example, if you can't create the wall or roof you want with the explicit Wall or Roof tool, you can create your own custom-shaped walls or roofs using the Model in Place tool. This tool lets you make a 3D solid geometry of the wall that you can then assign to the Wall category and that will behave and schedule as a regular wall. Figure 1.3 shows an example of custom-designed railings, curtain walls, and structural elements—all possible for a creative and engaged designer. These custom elements participate in the underlying data structure of Revit, making them schedulable and quantifiable.

FIGURE 1.3
Be creative, and
work out your
design solutions
in 3D.
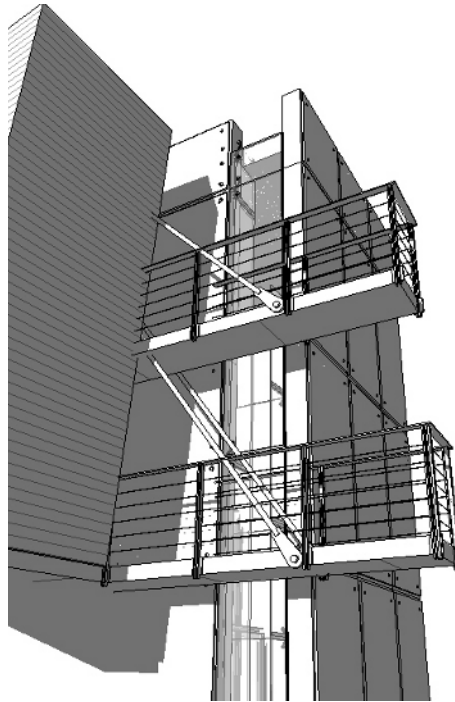
Every Element in Revit Has Properties

Throughout the design process of a project, you'll often need to adjust elements and change the model. Get used to the idea of clicking the Element Properties button to make interactive changes to the model. Better yet, map Element Properties to a keyboard shortcut. A member of the Basic Wall family, for example, has properties like width, height, bearing or nonbearing, demolished or new, interior or exterior, fire rating, and material. You can even define how layers wrap when inserts are placed in the wall, add integrated wall sweeps, and build stacked walls. Figure 1.4 shows the assembly options embedded in the type properties of a Revit wall.

FIGURE 1.4
The Element Properties dialog box of a wall contains many powerful features allowing detailed editing of the wall assembly.
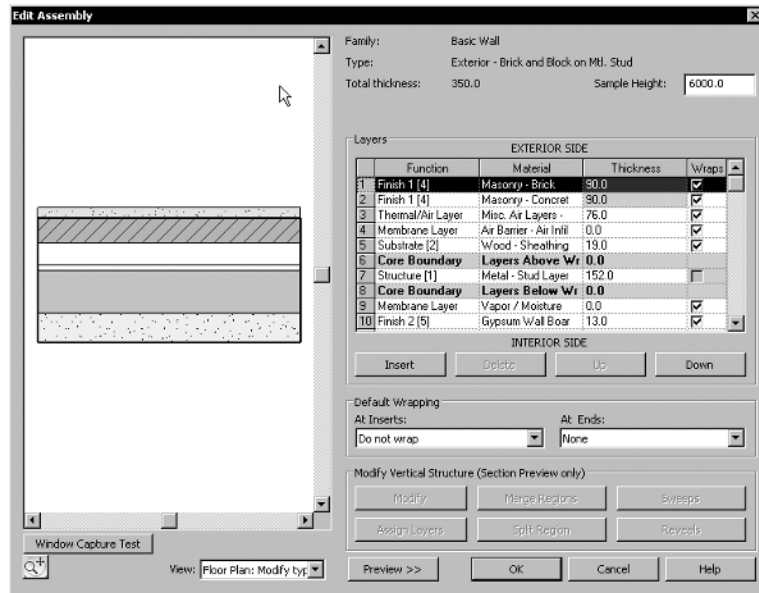
Elements Interact with Other Elements—All the Time

Remember: there is one model and many ways to look at it, called views; no matter in which view you change the model, the change will immediately be updated in all views. And in each view, you have total control over what information you want to display. Think of a view as a pair of glasses that can filter what you see—but the underlying model is still there, all the time.

A wall in Revit interacts with other walls to produce clean connections and appropriate levels of material abstraction. It connects to floors, levels, and roofs; forms rooms; and defines areas. Windows and doors placed in a wall move with the wall that hosts them when that wall is repositioned. Deleting a wall will delete all windows and doors in that wall and all dimensions associated with the wall. If you move a level, expect floors, roofs, walls, plumbing, and electrical features to also move as their parameters change. Keep the interaction of elements in mind, especially in multiuser scenarios where your changes to the model will affect many views at once.

Duplicating Views Takes Two Clicks

With Revit, you can duplicate floor plan views quickly, allowing you to generate plans as in-progress working drawings, others for presentation purposes, and still others for final construction documents (CDs). Note that this is very different from making a copy of a drawing of a floor plan: duplicating does not create any copy of elements in a model—what happens is that you are simply duplicating a view of the model and you can have as many different views of the same model as you wish.

Revit Fosters Problem Solving

An advantage of a BIM methodology is that you can't cheat the documentation of your design. Because the elements have properties based on real-life constraints, you'll find it difficult to fake elements within the design. When you get stuck trying to resolve a roof condition, it's most likely that you have a complex roof to solve. You can't just fake the elevations and call it a day. Of course, in CAD-based systems, faking annotations has always been possible and has no doubt led to some messy construction administration work. As you move into the BIM world, be prepared to take on some early design challenges.

Figure 1.5 shows what appears to be a simple house model, but it's more complex than it looks. With Revit, you model the dormers, the trusses, and the fascia and soffits. You need to determine how the walls and roofs connect to one another—and Revit is well suited to figuring these things out.

FIGURE 1.5
To build a BIM model, you need to solve problems in 3D space, from dormers to trusses.
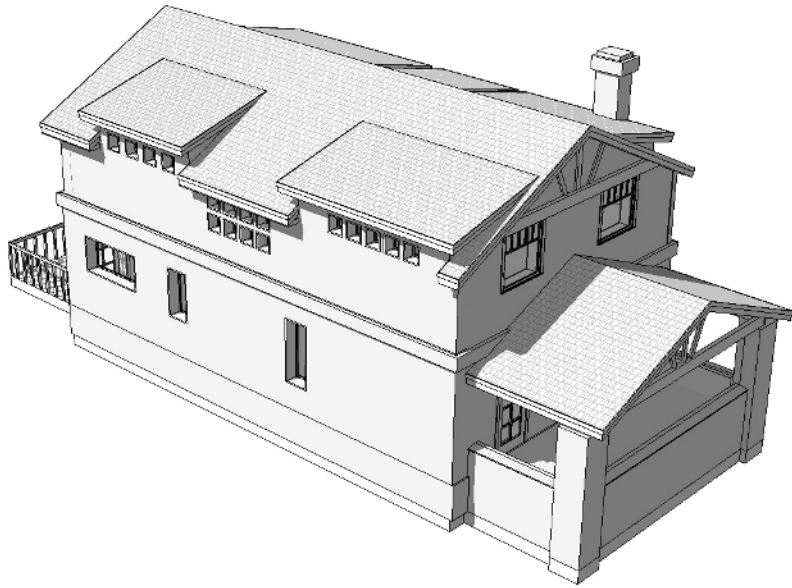
## Revit Lets You Leverage Other Tools to Support Your Workflow

Other software packages, such as SketchUp, Rhinoceros, Autodesk Alias Design Studio, Autodesk Maya, and Autodesk 3ds Max, are all excellent 3D modeling applications. While they can produce either quick 3D concepts or conceptually complex geometrical shapes, these modeling applications don't have the ability to document fully your design for construction, nor can they be leveraged downstream. Note, though, that even if these tools are not BIM, they can still play a role in a BIM workflow; many architects use them to generate concept models that can then be brought into a BIM application and progress through design, analysis, and documentation. If you prefer to work with other tools for concept modeling, doing so isn't a problem. When the design starts to gel, import the geometry into Revit, convert the imported conceptual models into real building elements, and start taking advantage of BIM.

Finally, not everything in a Revit model is modeled in 3D. You can create pure 2D drawings, drafting views, and details in Revit; import existing CAD details; and reuse details from other Revit projects.

Revit Allows You to Draft

The tools may be a bit different than those in AutoCAD or any other drafting application, but there is nothing you can draw in CAD that can't be drawn in Revit. By using the intelligence of Revit families, you can build your details into individual components, thereby embedding drafting elements into the 3D object. Figure 1.6 shows an example of a detail drawn entirely in Revit.

FIGURE 1.6
2D details can be drawn directly over the 3D model, allowing you to add much more information to the model.
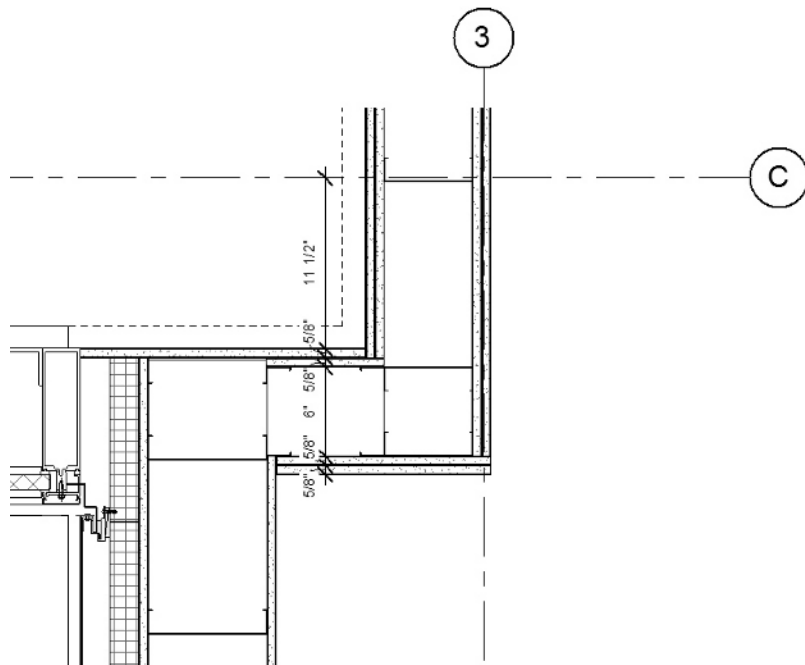
The Family Editor Is a Powerful Tool

Most elements (families) in Revit are made with the Family Editor and can be built with incredibly powerful behaviors. Don't be afraid to dig in to the Family Editor and explore your creative side. We've seen many beautiful families and clever tricks put to use that make Revit fun to use. Figure 1.7 shows a curtain wall system with nested panels and attachment clamps. As we'll discuss in Chapter 5 and reinforce in Chapter 10, creating such families isn't too difficult, and requires no programming or scripting knowledge. Using 3D modeling tools and parametric dimensions, you can create reusable and dimensionally flexible components for any architectural element. By taking your time, being patient, and tackling problem solving, you'll be producing custom content in no time.
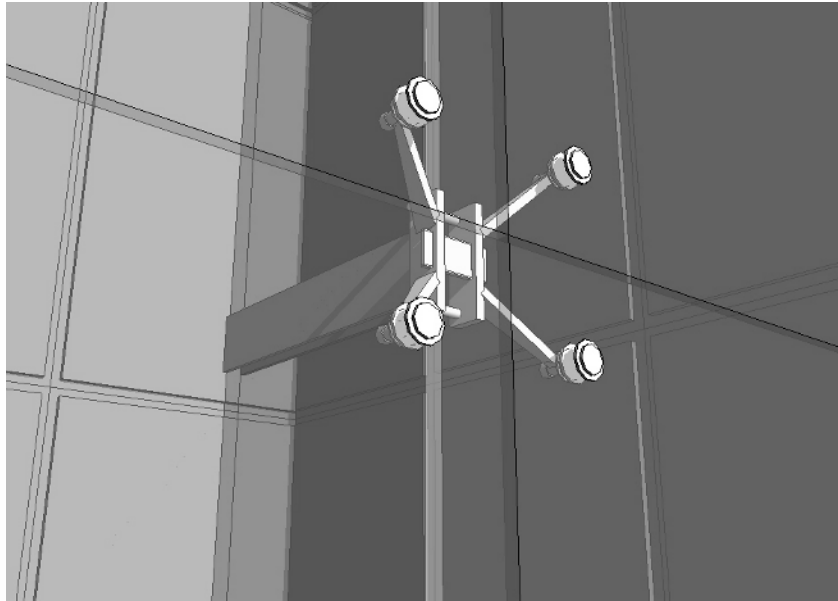
Revit Does Away with Layers and X-References

If you've already made the jump into Revit, then this will already be obvious: rather than user-defined layers, you use an intelligent architectural classification system to manage visibility, graphics, and selection. This may seem stringent at first, but once you get the hang of it, you'll see the benefits. Because a building model is an assembly of meaningful, to-be-built objects, you control the visibility and graphics of those objects using a rational list of well-understood categories. This also makes it easy to select similar elements and edit them. Figure 1.8 shows the list of classifications that manage visibility. You can't add to or alter this list, which means every project enjoys the same level of visual predictability. And of course, with an integrated model, you don't need to worry about referencing other drawings to keep the drawings up to date and in sync.

BIM Is More than a Technology Approach: It's a Change in Process

One of the powers of Revit is the ability to work in a single-file environment where the design and documentation of the building happens on a holistic model. This can be a disadvantage if it isn't taken seriously. Users who are quick to make changes without thinking about how such changes will ripple through the model can cause unintended problems. Revit is a parametric modeler that maintains relationships between building elements to streamline the design process. For example, deleting a roof underlay in a view doesn't just delete the roof in that view—it deletes it *everywhere* in the model. You need to think before you delete that wall or ignore that warning message!
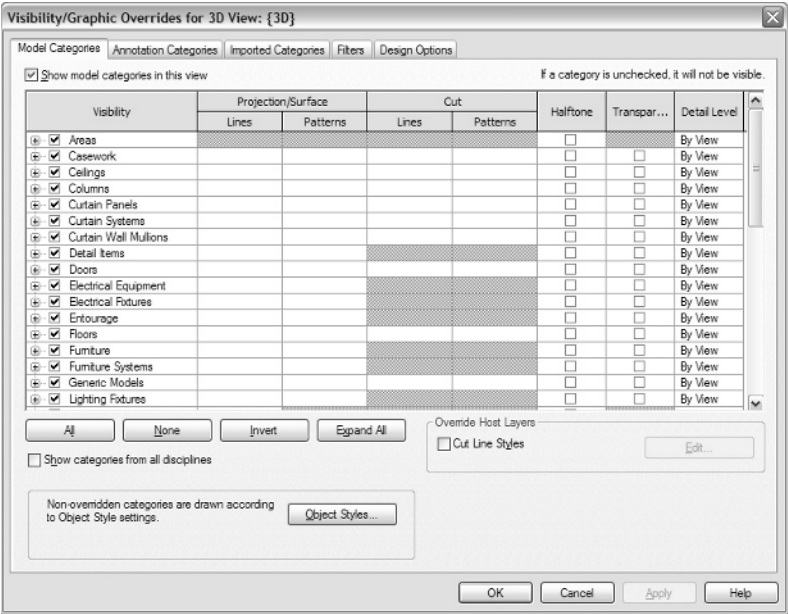
Be prepared to work in much tighter, more collaborative teams. As soon as you enter the BIM multiuser world, you absolutely need to be communicating with your team all the time. The changes that you make in the model will affect the whole model and other people's work. We think this is a great—perhaps unintended—consequence of moving into a model-based design paradigm.

Anticipate that tasks will take different amounts of time when compared to a CAD production environment. You'll perform tasks in Revit that you never had in CAD; and conversely, some CAD tasks that took weeks (such as chamfering and trimming thousands of lines to draw walls properly or making a door schedule) take almost no time using Revit. On the other hand, some tasks may seem to take longer in Revit. This may initially seem true, but remember that as you're modifying or adding something in plan, you're also adding it in section, elevation, and detail. Be prepared to discover and embrace new tasks with BIM that were never part of a 2D workflow.

In Revit you'll often feel as if you are working in traditional types of 2D views—just keep in mind that it's still a 3D model. Moving walls, windows, and doors in plan feels like a 2D operation, but of course it's not. If you've never worked in a model-based environment, it can be jarring at first to see the drawing you've been working on change as a result of an edit in a different view. As we mentioned, this becomes even more dramatic when you start working in a team and sharing a model. You'll learn that preventing movement of elements becomes just as critical as being able to edit elements in the model. Pinning down grids, levels, and exterior walls will become part of your workflow, especially in larger projects with many users working in a single file.

Revit Is the Most Advanced BIM Application

Revit is the most technologically advanced BIM application, and it's under highly dynamic development. What began as a single tool for architects has expanded into a platform that is the base for the structural and mechanical disciplines as well. The evolution of the Revit software platform will continue. As with any new technology, you'll run into problems, get flustered, and no doubt pull out some hair. That said, no other application on the market delivers the advantages of BIM as well as Revit does. Consider this for a moment: most other architectural products in today's market are based on technology that is 20-plus years old, whereas Revit is a new technology that was designed from the ground up as a BIM tool to specifically address the AEC industry. From its inception, Revit has had the goal of improving design communication, coordination, and change management. It has a patented parametric change engine that is unmatched in sophistication. It's also the leading software package in the international market. Revit is not the only BIM package out there, but we feel it offers the most holistic approach.

As you complete more projects with Revit, you'll begin to understand some of its advanced functionality. In this book, we'll delve into advanced concepts and guide you through some really cool features. We'll touch on the fact that Revit is now a technological platform that supports architectural, structural, and mechanical disciplines. The fact that you can share a model with your structural and mechanical, electrical, plumbing engineers (MEP) without any intermediate translation methods or change to the base environment is an exciting prospect, and one that will continue to drive changes in process.

Where Can You Go from Here?

Building information modeling is a revolutionary approach to the design, analysis, and documentation of buildings that takes full advantage of modern-day computational technology. At its core, BIM manages the flow of information throughout the lifecycle of a building-design process, allowing you to experience the building before it is built. Using BIM from early conceptual design through construction documentation and into construction administration and beyond, it's possible to better predict, plan, and execute the complex task of creating architecture to meet today's demanding requirements.

The flow of information in this new world consists of virtually all imagined inputs that go into a building design: the gross area of the building; its impact on the environment; the number of windows, doors, and plumbing fixtures; the cost of materials; the size of heating and cooling equipment—you name it. All this information is stored in a digital model—a virtual 3D database chock-full of information primed for extraction, analysis, and representation. The input turns into output in the form of coordinated document sets that can be shared across multiple disciplines and that serve as a centralized design-management tool for an entire project.

The AEC industry is at the cusp of a major shift in technology, and the resulting impact on building—and by extension the greater environment—will be revolutionary. We can no longer build without considering the impact of the building, without considering the building as part of a larger network of interconnected flows. The promise of BIM lies in the ability to visualize and understand how a building participates in these complex networks: how it performs, how it will age, and how it will accommodate and adapt to dynamic economic and spatial requirements.

Revit, along with a change in process, can change the way you do business, structure your office, present ideas to clients, win new jobs, and ultimately build a new architecture.

Armed with the skills you'll develop in this book, you'll be able to take Revit to the edges of creative expression and maybe create something as ambitious as the skyscraper in Figure 1.9.

FIGURE 1.9
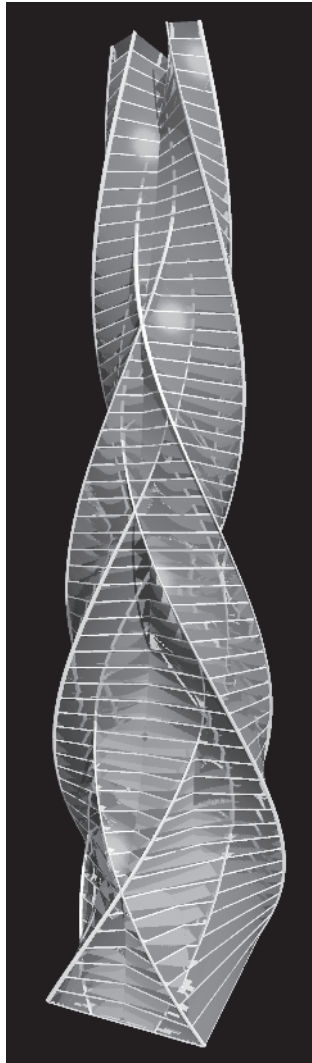Taking Revit to the edges of creative expression.

Image courtesy of Phil Read

The Bottom Line

Identify the advantages of building information modeling.　The traditional architectural design tools you've mastered are probably serving you well. New software and a new conceptual model of the building process will inevitably involve some adjustments, so they need to provide significant benefits.

Master It　What are some of the advantages of using BIM over traditional CAD tools?

Know what to expect from BIM.　A BIM project is based on a single, centralized database of information. You need to anticipate how that change can affect workflows based on more independent functions.

Master It　How can your work process be affected by the adoption of BIM?