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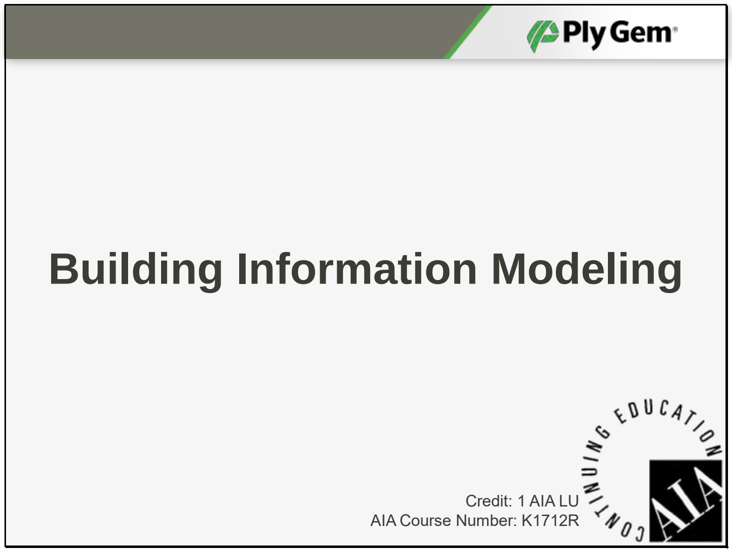

Welcome and thank you for your interest in “Building Information Modeling”.

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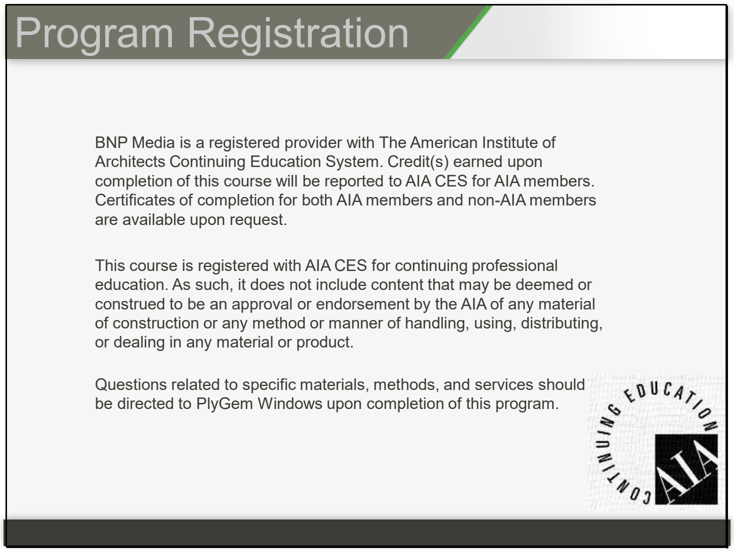

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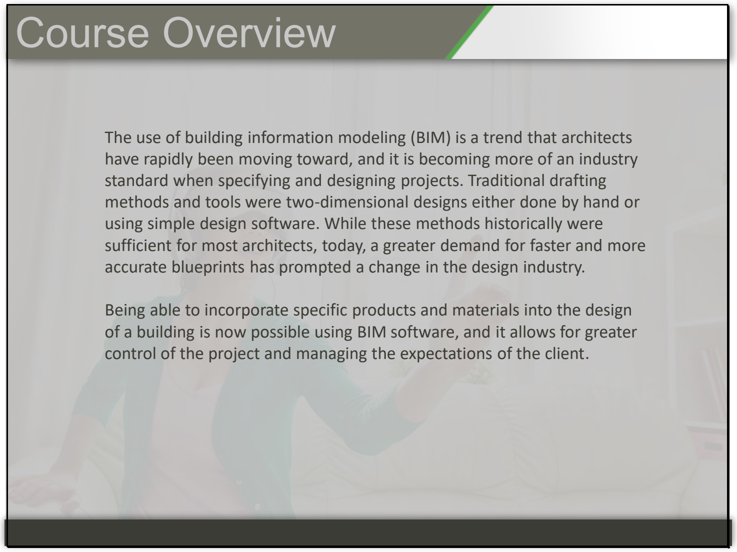

The use of building information modeling (BIM) is a trend that architects have rapidly been moving toward, and it is becoming more of an industry standard when specifying and designing projects. Traditional drafting methods and tools were two-dimensional designs either done by hand or using simple design software. While these methods historically were sufficient for most architects, today, a greater demand for faster and more accurate blueprints has prompted a change in the design industry.

Being able to incorporate specific products and materials into the design of a building is now possible using BIM software, and it allows for greater control of the project and managing the expectations of the client.

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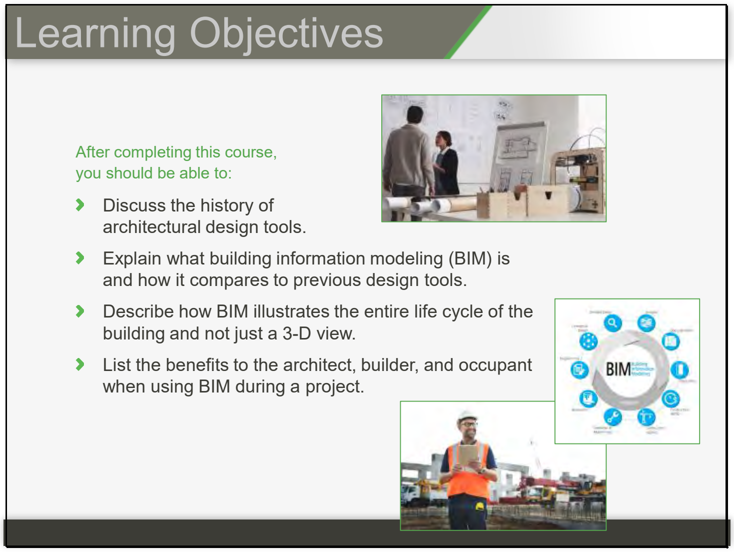

By the end of this learning unit, you should be able to:

- Discuss the history of architectural design tools.
- Explain what building information modeling (BIM) is and how it compares to previous design tools.
- Describe how BIM illustrates the entire life cycle of the building and not just a 3-D view.
- List the benefits to the architect, builder, and occupant when using BIM during a project.

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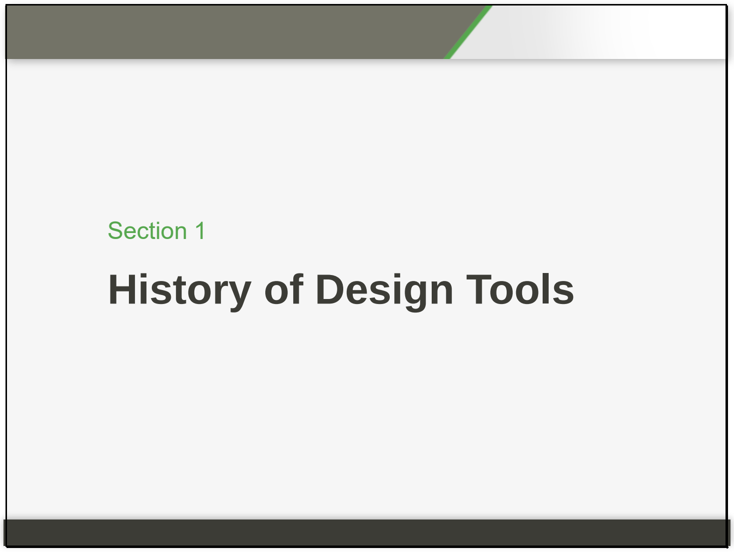

This section provides an overview of the history of architectural design tools and explains how different tools developed over time. The historical framework of architectural drafting and design provides a foundation for understanding how more modern tools enable architects to quickly and accurately complete their designs and building plans.

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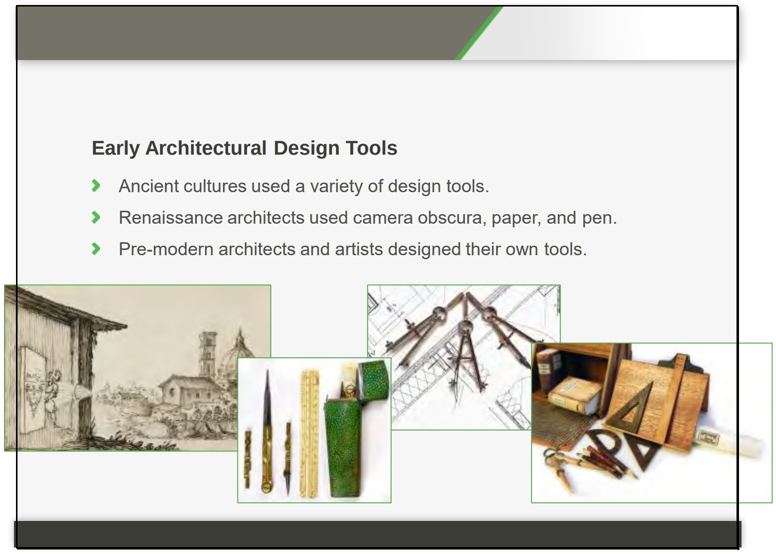

Architectural design tools were developed to help builders plan and standardize and reproduce the documents required to construct a building. Ancient Egyptians were known to use wooden corner rulers, and ancient Greeks used styli, scale rulers, and metal rulers. Romans used triangular rulers, compasses, and a ruler designed specifically to be used with a pen.

Renaissance architects used the camera obscura in tandem with pen and paper drawings as a means of producing precise reproductions of existing structures. Protractors have been used since the 13^{th} century to accurately measure and draw angles and arcs. In the 17^{th} century, an adjustable corner ruler was developed, as was the ruling pen, which could draw a line with a specific width. Other writing instruments included quill and ink pens and styli. Most builders and artists developed their own tools during this era.

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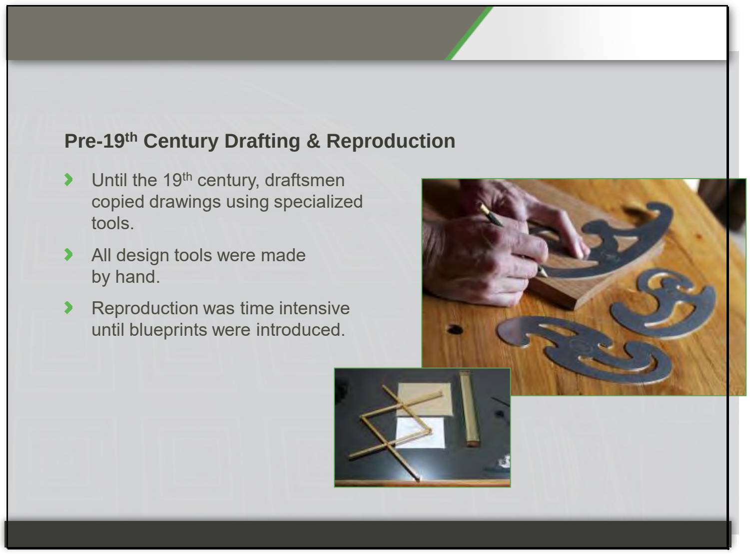

Pantographs were developed in the early 1600s and improved in the early 1820s with the advent of the eidograph, which improves the mechanical advantage by including a fixed point to the center of the parallelogram.

Draftsmen copied drawings to be distributed using specialized tools for accuracy. All tools were made by hand, usually for a specific project or need. Commonly used tools included French curves, set square, and bow compass. Initial designs and necessary reproductions were all done by hand, which was time intensive and error prone.

In the mid-1800s, different chemical and mechanical processes were employed to reproduce architectural drawings. The cyanotype, developed in 1842 by Sir John Herschel, allowed a drawing to be made on a translucent surface, which was then placed on chemically coated paper and then exposed to light. The blue tone of the paper introduced the term “blueprint” to the architectural field. Similar processes were used through the mid-1900s, but the term blueprint has remained.

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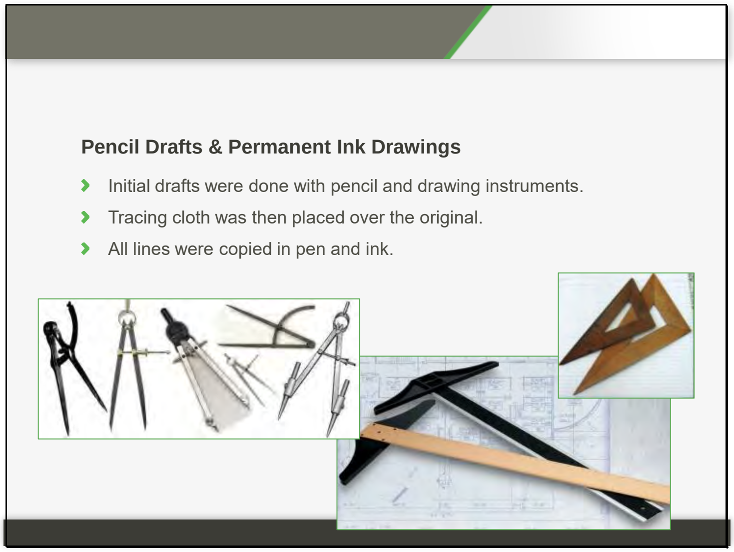

In 19th century architecture, pencil and pen were the key tools for drafting. Drafting guides and books explained how to properly sharpen pencils, and how to orient them to achieve even lines. Engineers or architects would carefully draw out detailed drafts using standard tools, such as the T-square, triangle, scales, and French curves, as well as compasses and dividers. The permanent drawing would then be created through a detailed process of tracing the original drawing onto a sheet of tracing cloth with pen and ink.

Technological advances included templates to standardize lettering and to make the tracing process more reliable.

Slide 10

During the late 19th century, many tools began to be standardized and manufactured. Architectural design tools were no exception, with manufacturers beginning to specialize. In 1854, British engineer William Stanley founded William Ford Stanley and Co. Ltd to design and manufacture precision drawing and mathematical instruments that could compete with French and Swiss instruments for quality and price. His company also produced and worked to perfect surveying instrumentation and telescopes through the 1860s and 1870s. Most tools were still manufactured by hand during this time. By 1875, Stanley had set up a factory (the Stanley Works), which produced technical instruments for many different fields; these instruments included technical drawing tools for architects.

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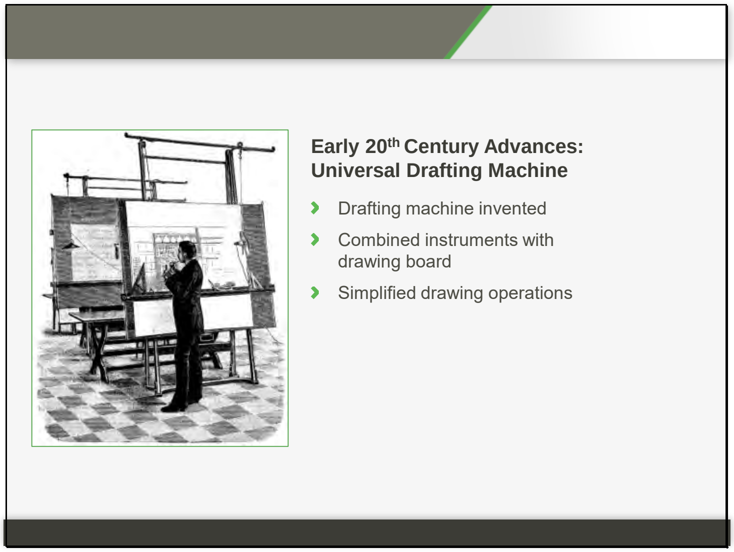


In 1901, Charles H. Little invented the drafting machine. This device consists of two scales mounted at a right angle on an articulated protractor head that allows for angular rotation. On the machine, the T-square, triangles, scales, and protractor are all combined and allowed the drafter to create perpendicular lines regardless of the orientation. The machine is typically mounted on a drawing board, and anchored to a base that can be tilted for easier drawing.

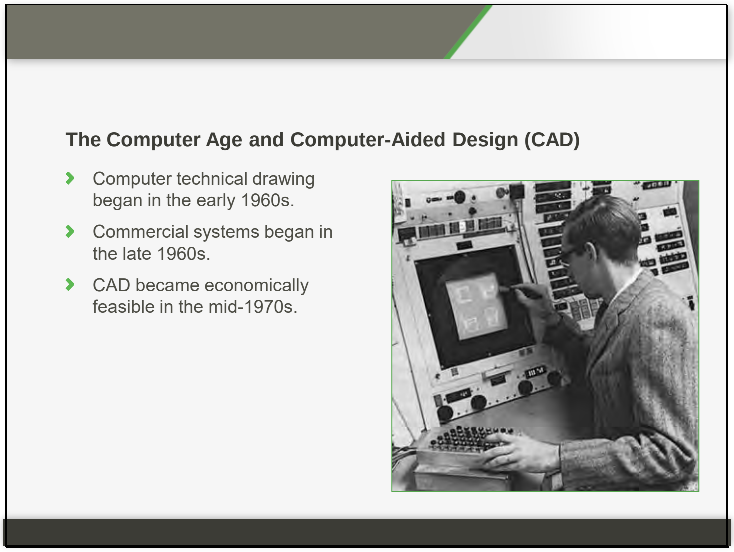
Drafting machines were widely used in Europe in the early 1920s and became a standard in architecture offices worldwide. They simplified drawing tasks previously done with ruler squares and protractors. Tasks such as drawing parallel and orthogonal lines, measurements of angles, and inclined lines at a preset angle were suddenly relatively easy to do, with significantly lower chances of error.

Slide 12

Throughout the first half of the 20th century, architectural design tools remained similar to what they were for the previous century. Drafting machines and blueprints were standard. Drafters or designers were specifically trained to master the mechanics of the drafting machine. Drafting tools advanced and were mass produced to improve standardization, but drafting and reproduction techniques were still limited to the work of a trained individual.

In the 1940s, architects began using diazo prints in place of blueprints. This new technique was known as “whiteprints” or “blue-lines” because of the blue lines on the white background. Diazo prints are still used today for some applications.

Slide 13



Computer aided design (CAD) was first developed as a concept and early prototypes in the early 1960s. SKETCHPAD, designed by MIT's Lincoln Laboratory, allowed designers to draw on a CRT monitor with a light pen. This and later programs demonstrated that drawn objects could be reproduced with changes to orientation, scale, and linkage. However, throughout the 1960s, computers were new and expensive, and software capabilities were low and limited. 2D reproduction of manual drafting, and the benefits of CAD were limited by the function and cost of computers and software.

Commercial CAD systems emerged in the late 1960s, and with them increased functionality. Design modifications and revisions became easier to do, and productivity increased as the software improved and more professionals learned how to use it.

Slide 14

2-D CAD Becomes Economically Feasible

- Mid-1970s CAD advancements
- CAD moves beyond reproduction
- Advanced 2-D drafting

Most CAD programs were in 2-D throughout the 1970s. CAD was first used commercially in large industries, such as automotive, aerospace, and electronics. In 1971, the computer system ADAM (Automated Drafting and Machining) provided advanced code.

By the mid-1970s, CAD systems moved beyond reproduction to more complex calculations, and more companies began developing software. As computer prices lowered and the functionality increased, the cost benefit of using the system prompted engineering and architectural design firms to move away from time-consuming manual drafting. During the transition away from manual drafting and design, calculations were still done by hand or by computer.

Advanced 2-D drafting systems such as Autodesk and AutoCAD emerged in the 1980s and included more features and modeling methods, as well as parametric linking of the features.

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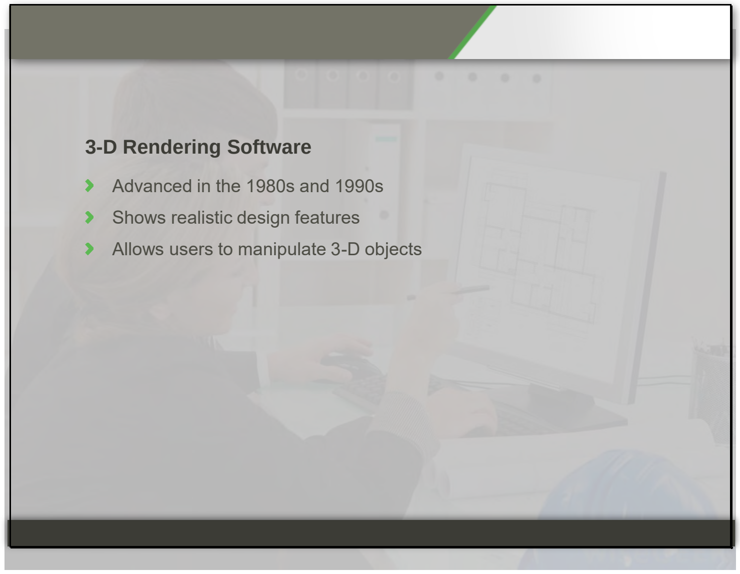

Early 3-D rendering software produced computer-generated images through different techniques. In the early 1980s, renderings were limited to flat images or images with basic shadows. As software advanced, new features allowed users to manipulate geometrically and topologically consistent 3-D objects. By the end of the 1980s, many different companies were producing CAD programs that were used widely in the engineering architectural fields.

Newer 3-D computer graphics processes are automated, and they convert 3-D wireframe models into 2-D images. These images may be photorealistic, or styled for a specific purpose.

Modern software allows for photorealistic renderings and panoramas, and can provide real-time walkthroughs or virtual tours of buildings and other animated effects.

Slide 16

This section will define what building information modeling (BIM) is and how it is similar yet very different than even the most advanced 3-D rendering software tools available today. Included in this section will be an overview of many of the features and benefits architects can expect from a BIM application. Specifically, this section will draw contrast between previous design methods and BIM applications potential.

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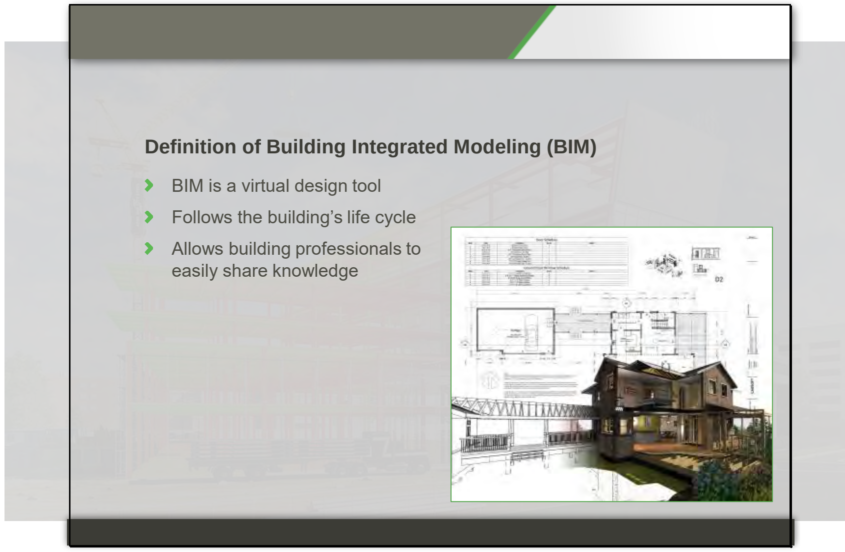

BIM is the process and practice of virtual design, construction, and management throughout a building's life cycle. The modeling platform is data rich and allows designers and building professionals to generate 3-D models (and drawings). BIM can include information about all aspects of a building from designs, decisions, product specifications, and building space use to operations management. The modeled information can also be used for building analyses—for example, to check building codes, calculate costs, or to simulate energy use.

Key BIM data includes the geometry of the project, the physical properties of the materials (e.g., construction materials, visuals properties), the types of buildings or spaces, and cost and time schedules. The object-oriented model is tied to a central database accessible to all project participants. The data can be used to generate high-quality 3-D renderings to present a building concept for a bid or to help architects visualize and analyze specific design elements, such as energy use.

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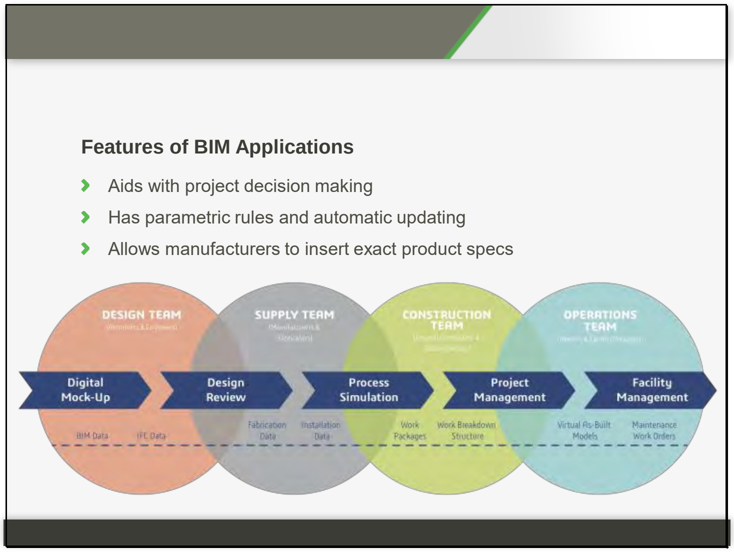

BIM enables project-wide decision making, and the virtual model can be easily handed off from the design team to other building professionals, such as the contractors or owners. Project information remains intact, and thus helps each professional understand the building specifications throughout the building's life cycle.

BIM represents design as a combination of "objects" that can range from generic shapes or spaces to product-specific features. Each object contains data attributes and parametric rules, making them intelligent building components. When one object (for example, the representation of a door) is changed, related objects (for example, a wall) will change to coordinate. Views are coordinated automatically through the BIM.

For manufacturers, this functionality means that they can drop in exact product specifications to the program and have the outcomes calibrate to that product.

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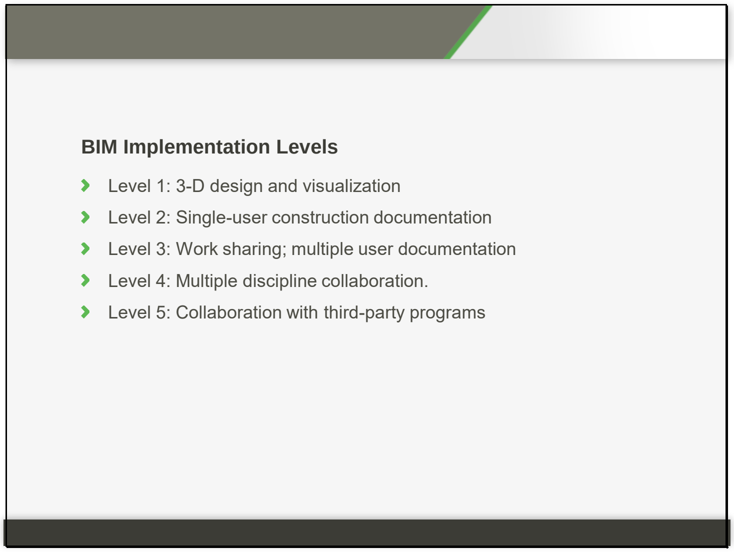

BIM levels are dependent on the project requirements and on how much collaborative work needs to happen between different professionals. Level 1 involves the architect's early-stage 3-D design and visualization process, the results of which can later be shared with the team. The next level involves a single-user construction document that can be used as a the basis for work sharing from multiple users, thus resulting in more complex documentation. Level 4 implementation brings in other disciplines involved in the building project, such as the models from structural and mechanical engineers. This information can be combined with the architectural models to create a comprehensive system. Finally, BIM can be implemented to assist collaboration with third-party programs for energy modeling and overall project implementation.

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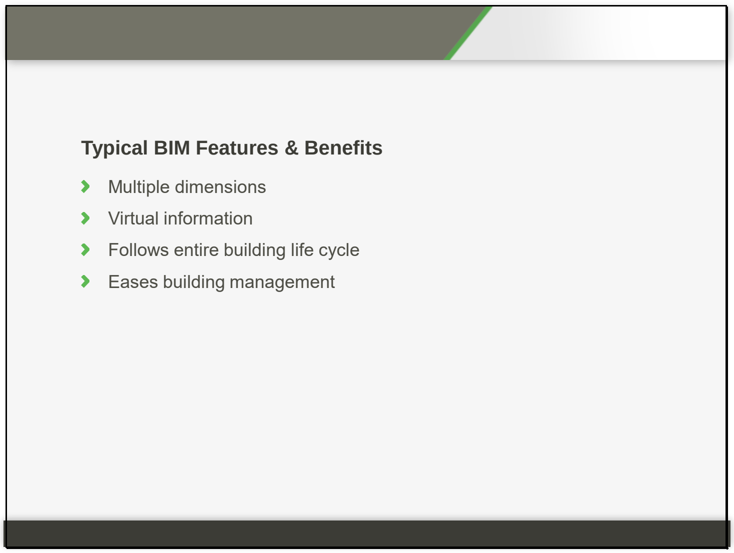

BIM offers architects and building professionals many beneficial features. For example, BIM includes time and cost features for estimates and scheduling, product management for purchasing, and performance analysis, among others.

The virtual model means that designers can easily hand over project details in the form of the model to the contractor, who can then share information with relevant stakeholders. Building data is all in one place and isn't likely to get lost.

BIM can follow the entire building life cycle from planning to maintenance and operation, even to demolition. This all-encompassing system gives professionals a complete view of the project. A BIM manager helps facilitate information through the building life cycle. This job requires that the manager use BIM as a benchmark to develop and track object-oriented BIM against the actual progress and performance objectives projected by stakeholders.

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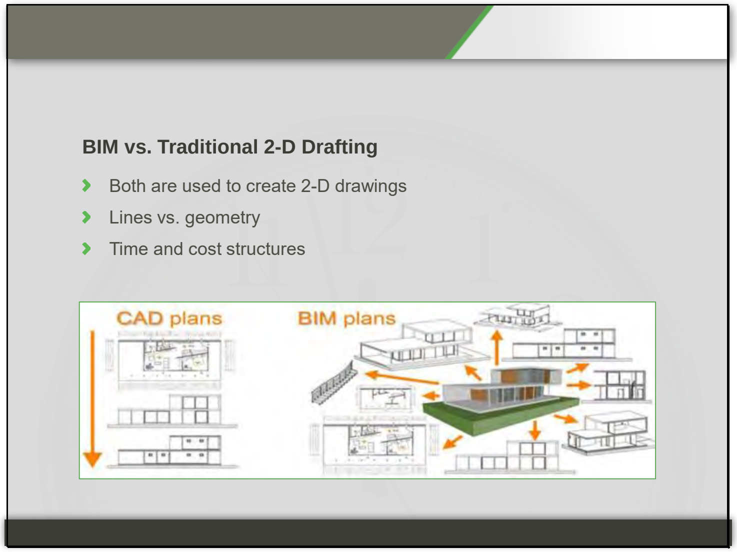

Both BIM and traditional 2-D drafting work well to create construction documents such as floor plans, elevations, and details. One way that BIM and 2-D CAD differ is how they deal with geometric shapes. 2-D CAD software such as AutoCAD is limited to using lines to create geometric shapes that represent real objects. BIM platforms, however, involves geometry that includes real-life information, such as material weights and volumes. BIM also makes modeling easy, and it has the added features of generating project cost structures, allowing for collaboration and managing changes within the project. All objects in a BIM project are linked, and changes in design are automatically updated in other areas, such as schedule and cost. This function is known as bidirectional associativity, and it is one of the main reasons architects shift to BIM. For example, in a BIM project, a change to a window will result in an automatically updated window schedule. A change to a window in a CAD project, however, requires that the plan, section, election, and schedule all need to be updated separately. In short, BIM guards against mistakes all while saving the architect time.

Slide 22

While 3-D drafting systems such as 3-D CAD are still very useful for designing building documents, they are limited in comparison to BIM platforms. Where 3-D CAD systems identify individual objects (e.g., walls, bricks, etc.), BIM can easily integrate manufacturer product specifications right into the design. These specifications go beyond the basic objects available in CAD systems. More importantly, BIM is a process that considers the full life cycle of the building, not just the initial design. This means that every element of the building design can be specified for performance requirements (e.g., energy efficiency, thermal, sound). Once the building is complete, those requirements can be verified. BIM streamlines this process for building professionals.

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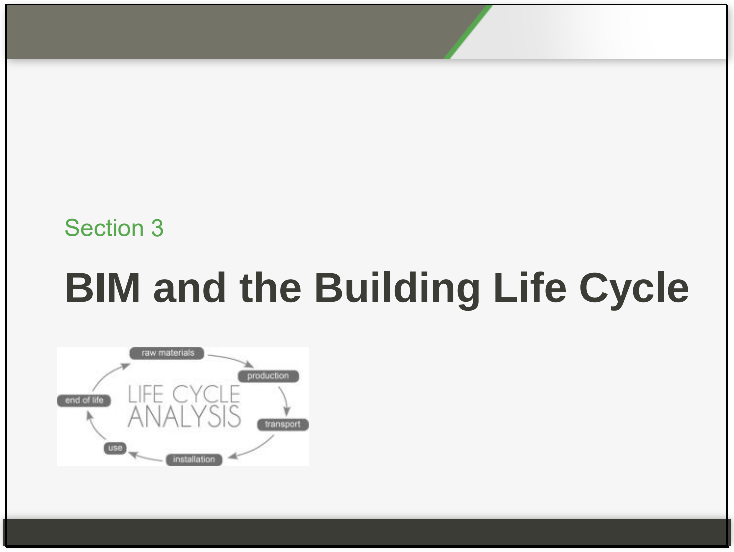
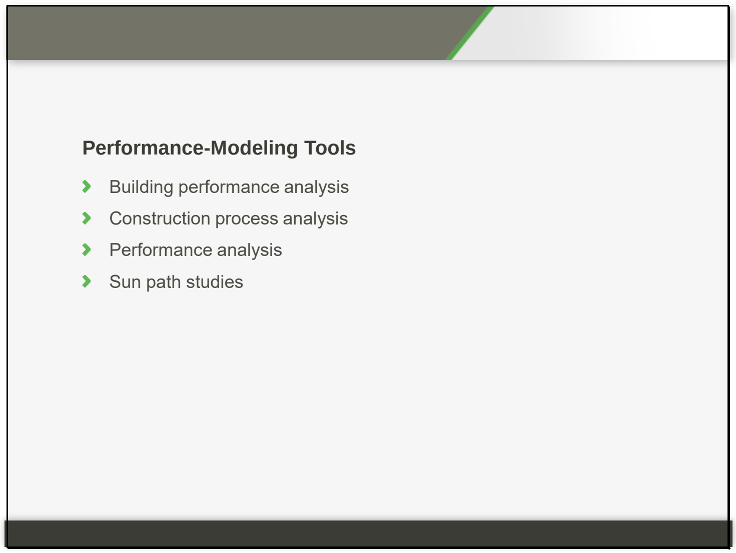


This section will explore not only how BIM can help with 3-D drafting of a project but also how it can actually help model the entire life cycle of the building. BIM differs significantly from design tools such as CAD because it is able to use actual products and materials that will be specified in the construction of the project. This enables the architect to fully configure not only how the building will appear, but how it will function from an expected energy efficiency, comfort, and health standpoint.

Slide 24



Many performance-modeling tools exist as plugins for BIM. These tools can be used for building performance analysis (BPA), which can help architects design more sustainable buildings or assess construction practices and eventual performance.

Designers can use the complex information available through BIM such as the type of space, specific properties of materials, a building's physical location with typical environmental temperatures, and sun and wind patterns. With this information, they can simulate whatever project requirements they might have. For example before construction, designers may want to know optimal HVAC size or what the structure's air flow, light levels, or estimated water use may be. For sun path studies, BIM allows architects to place their model in the exact geographic location and orientation that it will have in the real world, and see how it reacts to the sun position on any day or time of the year. BIM allows these analyses to be done prior to construction as well as after. Such studies are usually done at the same time as energy analyses.

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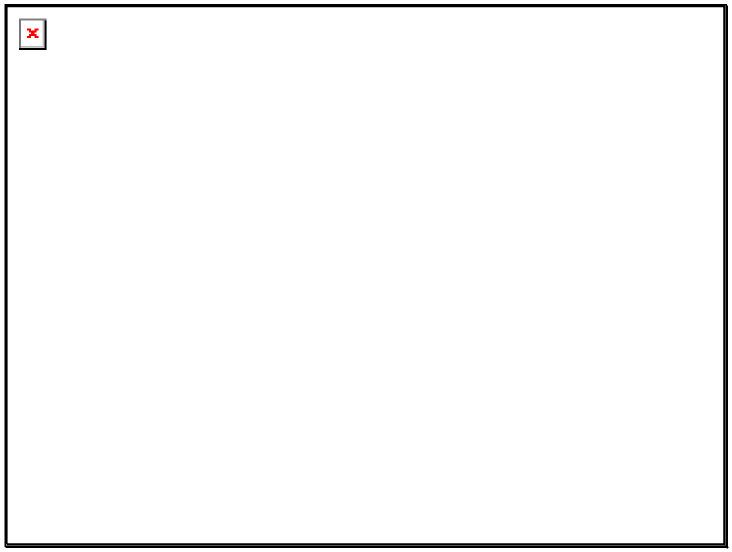

BIM’s versatility throughout the project life cycle means that it can help building professionals best identify actual products that can best be used in the design. For example, a project engineer may wish to identify (and model) early in the process the specific pipes, HVAC ductwork, or other elements to be used in the building. To do this, they may use a discipline design model. Both manufacturers and contractors can benefit from BIM functionality as well as create customized assemblies for a building by using a fabrication mode. Finally, the entire building team may wish to share information through an aggregated design model. This type of model allows team members to collate their models so that they can coordinate the various elements of the project and show the combined work in a 3-D model. BIM allows teams to iterate their designs and benefit from the integrated supply chain.

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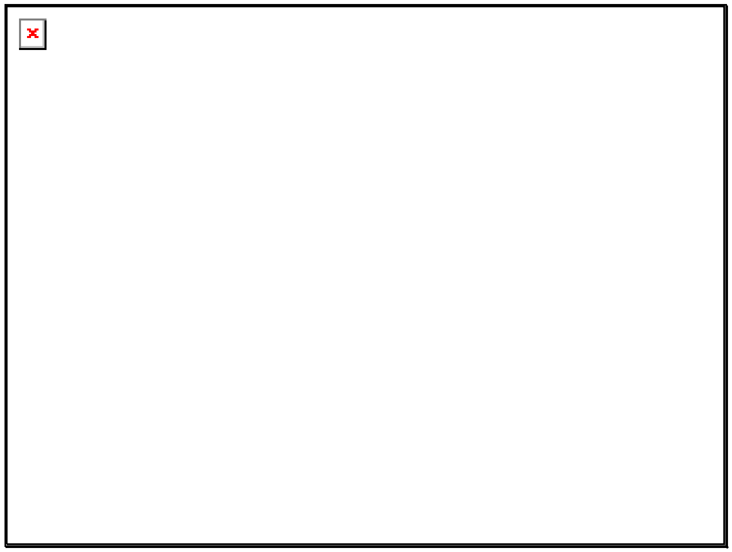

When BIM is combined with energy analysis models (EAM), building professionals can collaborate to conduct energy modeling on a given project. Energy modeling early in the design process can increase building energy efficiency, and engineers and architects will have access to modifications and can edit as needed.

Energy modeling can help team members and stakeholders identify and compare energy-saving options (e.g., windows, doors, HVAC fans), show the potential impact of design decisions throughout the building life cycle, and inform decisions on eventual repairs. Furthermore, energy modeling is a requirement for LEED certification.

The energy model will be different from the paper document model provided by the architect and engineer and may look completely different from the actual design. The key is that it contains the correct information for the analysis.

Slide 27

Buildings are designed for occupants, and the comfort needs of those occupants must be met. The three basic comfort metrics used in models are thermal, visual, and acoustic. Comfort modeling is important to help ensure that occupants are in happy living or working environments, but these issues are also often linked to energy use and may be coordinated with energy modeling.

BIM helps building professionals model comfort aspects in a sophisticated way not possible with 3-D CAD. Because BIM can integrate data about specific materials and products, designers can easily model the impacts of the structure before construction.

Thermal considerations such as temperature, airflow, humidity, or even radiant surfaces can be modeled. Architects can model visual aspects, such as windows or artificial lighting, and consider the energy implications. Finally, acoustic comfort can be modeled to help designers best choose acoustic tiles, include barriers, or design rooms to reduce sounds.

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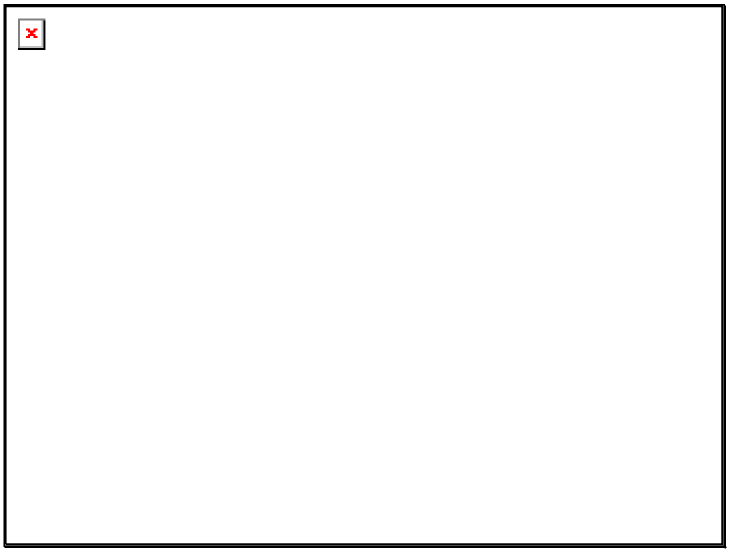

BIM's role in modeling for health and human welfare and safety can be tremendous. Architects and builders can help reduce risks and communication mishaps simply by having explicit design information available to each other within the same virtual space. This point alone can help address other elements of quality control.

While air quality can also be considered a comfort aspect of a building, it directly impacts the health of the occupants through proper airflow and circulation. BIM can be used when designing for emergency situations such as fires or natural disasters. The model can address all aspects of the building, such as entrance and egress, sprinkler systems, and stairwell design and safety, not to mention the flammability of internal building materials. Similarly, BIM can be used to help design more accessible buildings.

Finally, BIM can help make sure building operations run smoothly, which can enhance the overall wellbeing and safety of the occupants throughout the building's lifetime.

Slide 29

BIM is useful for helping the project team set and achieve customer expectations. The team can develop and produce specific documents relating to all aspects of the project and easily provide customers with that information. Estimates for cost and schedule can be more accurate because of the team collaboration via BIM, and thus the customer can confidently go into the project.

Building professionals can also generate mid-project reports using metrics to assess quality as an ongoing concern. The project team can address and resolve any issues that may arise without having to contact customers, thus reducing customer concerns.

Finally, BIM platforms provide a stable record of all aspects of the project, all of which can be used at the end of the project to measure overall performance but also as proof of meeting the initial expectations.

Slide 30

This final section will explore the many benefits of using BIM as a process and platform to design a successful project. Included in this section will be a list of benefits to the architect, including accuracy of drafting, speed of process, and simple collaboration and sharing mechanisms when working with builders, other design firms, and clients.

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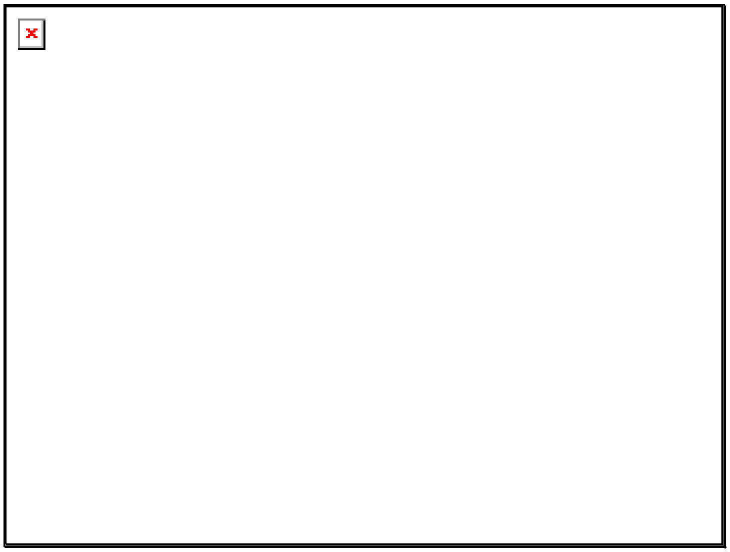

For builders, BIM offers multiple production and scheduling tools, including window schedules, elevations, takeoff sheets, order-placing tools and project level data, all contained in one central application. For future occupants, BIM allows for a better understanding of specific product and material choices, and helps set more realistic and reasonable expectations for project completion.

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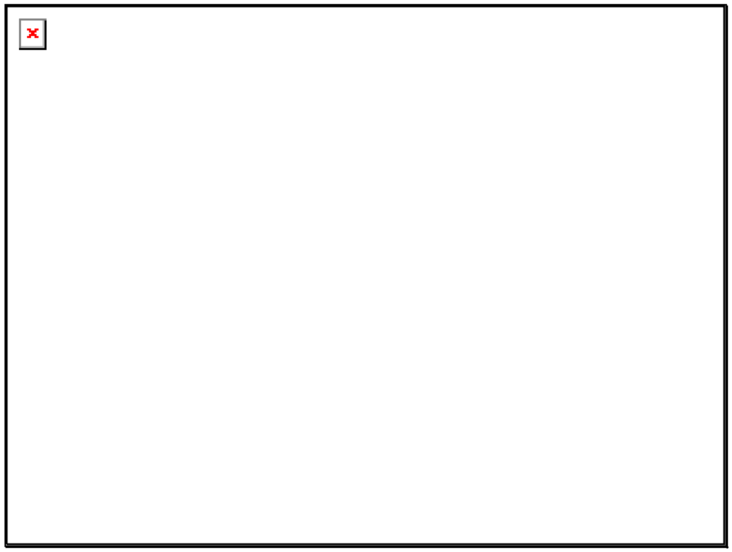

BIM platforms allow architects to design and develop much more realistic and accurate renderings than possible with CAD software. With BIM, they can quickly communicate with the client via 3-D images during the design process. This benefit aids in the overall project communication and helps professionals down the project line better visualize the original design. Moreover, it helps reduce conflicts between members of the project team early on, and thus helps reduce both errors and omissions. This benefit is seen directly through reduced project time, more accurate material estimates, and better predictions of overall costs and schedule.

Another way that BIM can help the individual architect is through greater efficiency. BIM makes it easy for architects to do the work that once required a team of several people. This way, they can either provide more services for the same fee, or they can reduce fees to become more competitive, all while maintaining close control over the project.

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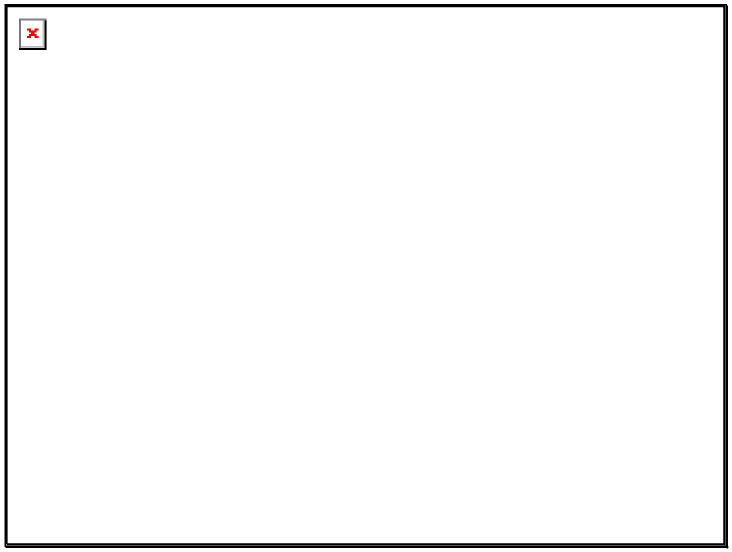

Two other useful advantages are clash detection and bidirectional associativity. Clash detection is used when the architectural, mechanical, and structural models are brought together, and it shows all of the places where a duck and beam collide. BIM uses bidirectional associativity by storing the model information in a single coordinated database, which means that any revisions or changes are automatically updated throughout the model.

A final advantage is that BIM's centralized database means that detailed 3-D presentations are easy to generate, and the data can be accessed anywhere, from any device.

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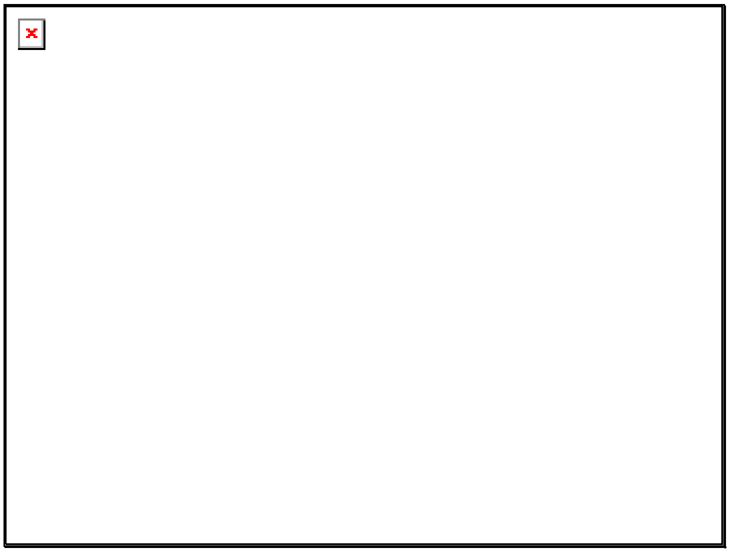

As projects get underway and the design moves from the architects to the builders, BIM remains highly beneficial for the architects. Aside from allowing individuals to collaborate and communicate in real time as the project progresses, BIM helps by making submodels easy to generate. This makes for a more efficient construction process. Project management overall is also greatly improved over CAD-only projects through centralized data-sharing and by having documents accessible for the whole team.

Another advantage during early construction is that BIM can be integrated with point cloud laser modeling. This technique uses a laser instrument to record information about an existing building and have that data be imported into BIM as a point cloud model. The outcome is a highly accurate model of the existing building.

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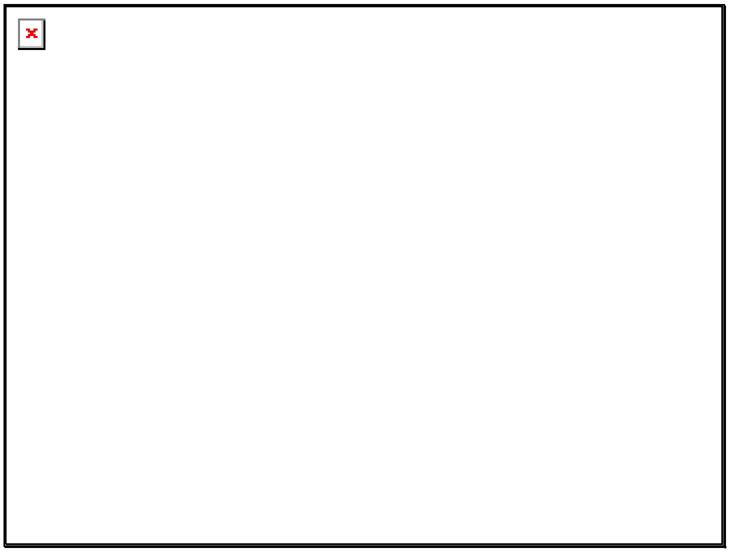


When BIM is used for building projects, it allows architects to easily do quality-control checks throughout the process. As the building nears completion, this information is particularly useful to verify that everything has gone according to the original plan. More importantly, this information can be given to the client, who will benefit from having accurate updates with specific timelines.

Another benefit architects and architectural firms get from using BIM is an organizational image of quality, efficiency, and overall good work. This in turn can result in referrals and additional assignments, as well as eventual increased profits.

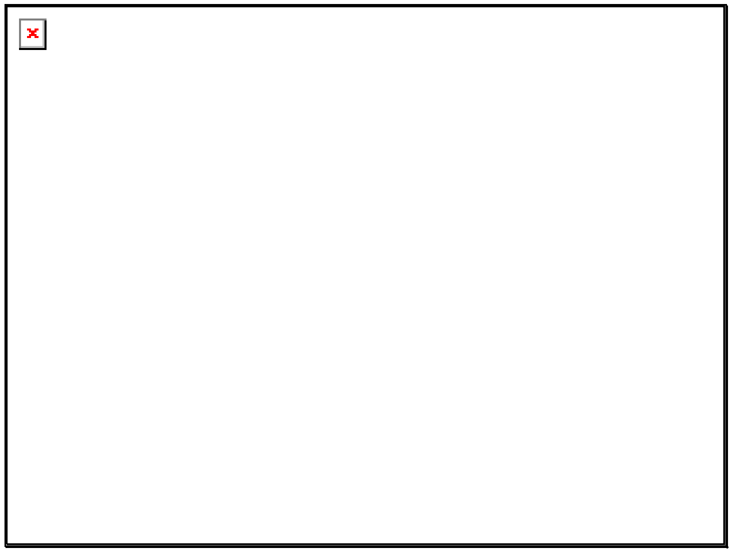
Slide 36

Much like the architects on a project, builders benefit tremendously from the easy communication offered by the BIM platform. This streamlined communication and access to real-time changes with plans means that there are fewer conflicts and thus reduced changes during construction.

The production and scheduling tools available through BIM also help builders plan more accurately the specific materials and products needed for construction. The details of these tools are discussed in the next slide.

Between knowing the materials and precise quantities, and being able to schedule project timelines more accurately, builders are able to better predict the outcomes of the project. More often than not, that outcome is higher quality than buildings constructed without the benefits of BIM.

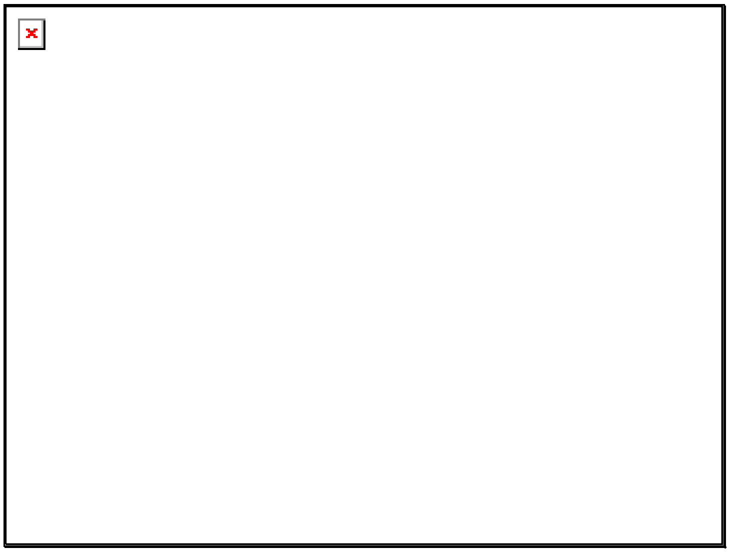
Slide 37



The variety of production and scheduling tools available to builders can help during every phase of the project. For example, BIM makes it easy to produce elevations, takeoff sheets, and window schedules. When it comes to ordering products, BIM lets the architect choose the exact make and model for a project online, and that information is incorporated into the centralized project data. This efficient process means that architects have more time to do more detailed drawings.

By having precise product and scheduling tools, builders can prevent delays that may occur when product information isn't communicated well. BIM helps ensure that the correct products are ordered on time, which in turn helps facilitate installation schedules for major components such as windows and doors. More importantly, BIM helps all members of the team be confident that the information is more accurate than without BIM.

Slide 38



Some of the final benefits for builders come from being able to have more prefabricated parts available for the project. These parts can be ordered in accordance to the project specifications and can reduce construction time. Another benefit of BIM is that because the overall design and construction is streamlined, the project outcomes can be more easily predicted. And, once the project is finished, the completed infrastructure often performs better when compared to projects not done with BIM.

Much in the same way that BIM can help architects secure new jobs based on the quality of work, BIM can always help builders and contractors gain stronger reviews on their work. When building materials and costs are accurately predicted and the project is kept on schedule, everyone involved in the project wins.

Slide 39

Subcontractors who use BIM benefit not only by being virtually connected to the entire building process and building team but also by making their own business practice more efficient. This efficiency is an excellent marketing tool for future projects.

When using BIM, subcontractors are linked into all aspects of the project. From design and engineering to manufacturing and procurement, they improve their fabrication process. Subcontractors can easily prefabricate coordinated systems, which in turn shorten lead times and help reduce overall project costs.

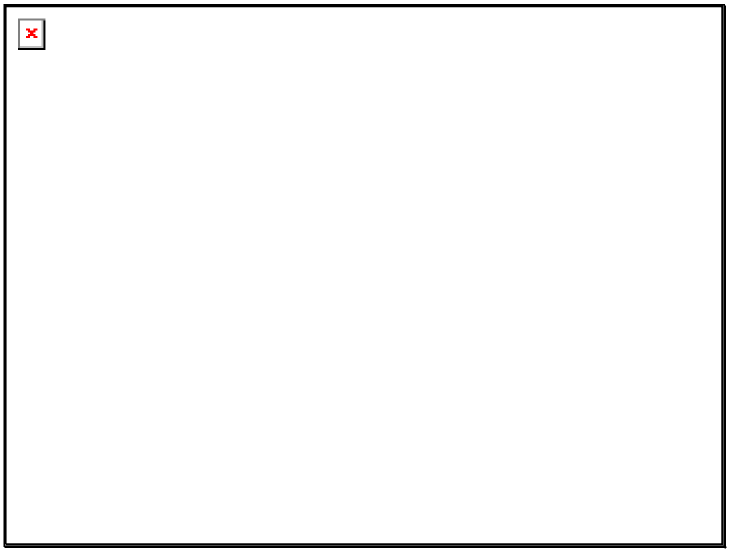
A final benefit of BIM for subcontractors is that it adds autonomy to their practice. They are able to design, engineer, construct, and fabricate the specific elements for the project. This includes being able to provide specific products as identified by the design team.

Slide 40

BIM helps the clients focus on important aspects of the complex design and construction process. For example, they are able to select precise product models and materials and understand how and why those choices work well (or not) for the design. This information eases any conflicts between the building team and the eventual occupants, because realistic and reasonable expectations can be set at the start of the project, which limits challenging surprises during construction.

For all clients, but especially clients of large projects, the benefits of BIM ultimately come down to saving money on the entire project. For example, a client for a large condominium construction may save money both during design and construction but also through building operations, all from using BIM at the onset of the project.

Slide 41

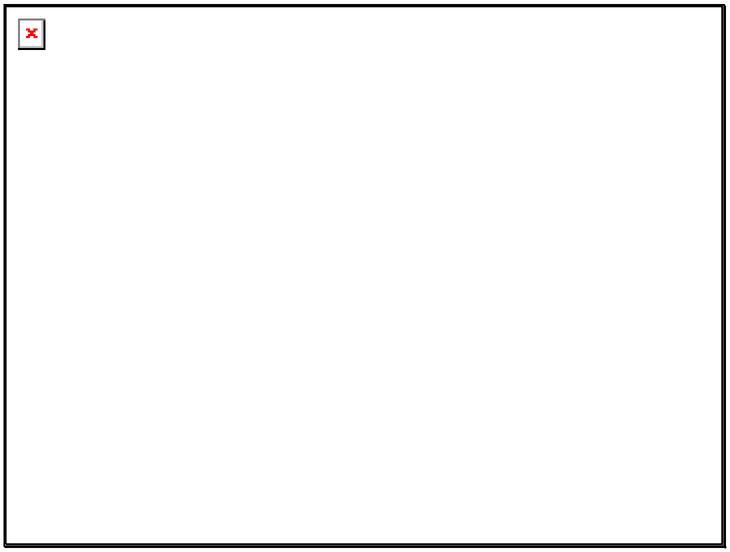


Building managers can use BIM as a facility management tool. For example, BIM can standardize representations of all aspects of the building, from the future occupants and space to the operational needs of the building. BIM enables interoperability with systems such as building management, energy management, and occupant comfort, health, and safety throughout the building's life cycle.

The visual element of BIM can helps building managers see where space can be used more efficiently. By modeling plan scenarios and better configured spaces, building managers can identify and prevent potential conflicts concerning space requirements, and adapt to changing space purposes.

BIM's integrated system also aids building analysis for energy-saving initiatives such as LEED. Models can be updated as new data becomes available and as new programs are developed. This can help ease the certification process.

Slide 42

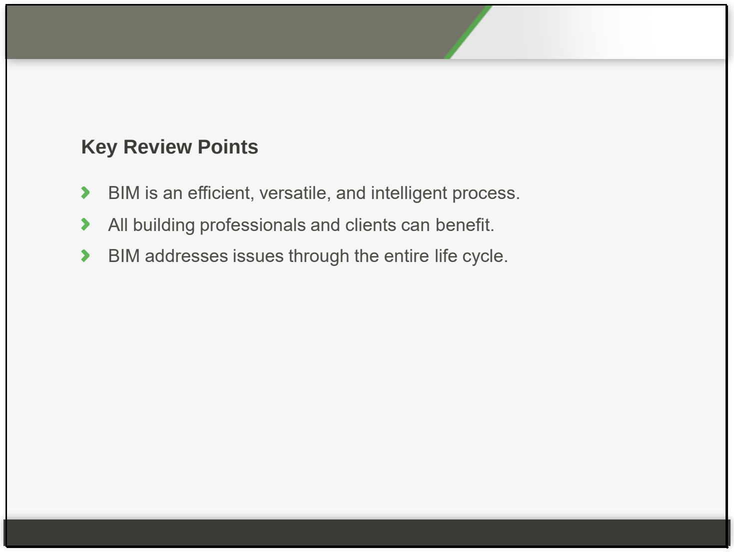


Future occupants of a building benefit from BIM by understanding how and why products and materials were chosen, having realistic expectations about the project completion time, and ongoing care of the building.

Building occupants benefit from the original design and construction, which ideally has taken into consideration elements of energy consumption and overall building comfort. The BIM process helps streamline these elements during design and construction, and thus occupants benefit from an appropriately lit, heated, and overall comfortable space. These benefits may also include optimized health and safety considerations, such as well-designed entrances and egresses, fire safety, and accessibility.

Finally, occupants benefit from BIM’s use throughout the building’s life cycle. This includes easier routine maintenance, tracked system updates, and a safer and better occupant experience.

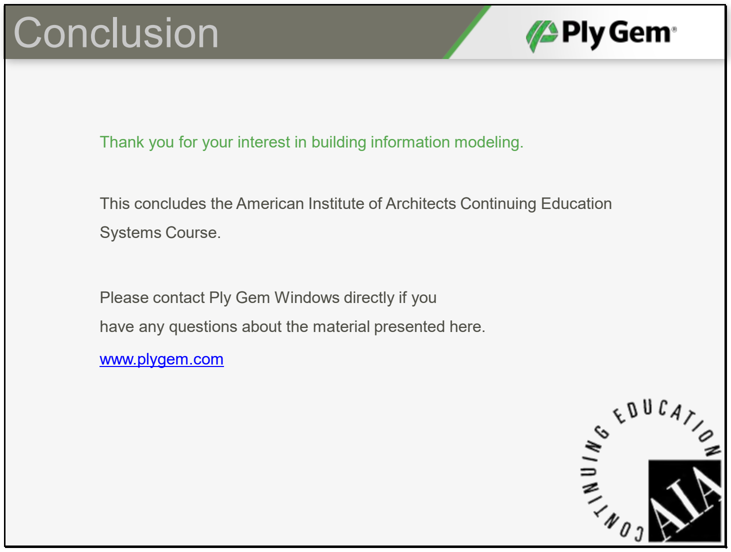
Slide 43



BIM holds many advantages over 2-D and 3-D CAD systems. Rather than providing just images of a design, it offers advanced functions, such as scheduling, pricing, and performance modeling for analysis. Its centralized data improves project efficiency that benefits every department of a project team, from designers to building managers.

BIM addresses issues through a building's entire life cycle. Initial models can help predict and design for occupant comfort and safety, as well as eventual building repairs and system updates.

Slide 44



Thank you for your time and interest in building information modeling. This concludes the AIA Continuing Education System Program. Please contact PlyGem Windows directly with any questions about the material presented here.

You will now take a 10-question quiz.