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Building Information Modeling Is Revolutionizing Construction

Reduces costs, increases quality and reduces conflicts

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Building information modeling (BIM) is the most exciting development in construction in a generation and is transforming the way projects are designed and built. By creating a three-dimensional virtual simulation of a construction project, BIM has the potential to revolutionize construction by reducing costs, increasing quality, reducing conflicts and even achieving designs that would be impossible without this technology. In the very near future, BIM will overwhelm the construction industry and become the standard of practice for design and construction in the 21st century.

BIM is a technology that uses construction information to form a three-dimensional simulation of a construction project. BIM does not provide just a three-dimensional depiction of a construction project. Rather, BIM creates a digital simulation of a structure that can be digitally viewed, tested, modified, redesigned, constructed and deconstructed.

BIM is fundamentally different from traditional design tools. Computer Assisted Design (CAD), used overwhelmingly by most designers for decades, depicts construction elements with lines that define a structure's geometry. In contrast, using BIM, each element of the structure is an "intelligent" object containing a broad array of information in addition to physical dimensions. Each element in a BIM model "knows" how it relates to other objects and to the design in general. With BIM, walls are objects which can be stretched, joined and moved, and which "know" that they have certain properties. For example, a wall in a BIM model "knows" that it is supposed to extend from the foundation up to Level 1. If either of those parameters changes, the height of the wall will automatically adjust to match. Similarly, doors and windows "know" their relationship to the wall in which they are placed and behave accordingly.

BIM is the most powerful tool yet conceived for improving the construction process. Designers can use BIM to explore alternative concepts and optimize their designs. Contractors can use the model to "rehearse" construction, coordinate drawings and prepare shop and fabrication drawings. Owners can use the model to optimize building maintenance, renovations and energy efficiency, as well as to monitor life cycle costs. BIM allows for collaboration among designers, constructors and owners in ways the construction industry has never known before.

The potential benefits of BIM on construction projects are startling. Some uses of BIM are listed below.

Single Data Source: All construction projects require access by many parties to the same information. Under prevailing practices, the identical information is repetitively entered by separate parties into separate computer programs, each designed to provide a specific analysis. Every repetition is an opportunity for error.

In contrast, BIM allows project parties to capture everything known about a building in a single project database. Plans, elevations and section drawings, all generated from a single design model, are then always consistent. By having

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a single, unified data source, the risk of errors in data entry or translation is greatly reduced, and the risk that parties will proceed based upon conflicting information is minimized.

Clash Detection: In complex construction projects, design drawings must be coordinated to assure that different building systems do not clash and actually can be constructed in the allowed space. System conflicts are a primary source of contractor claims and unexpected delays. The traditional approach to system coordination, which has been used for decades, is to overlay two-dimensional drawings on a light table, or to merge drawings for each system into color-coded composite drawings. These processes are tedious and fraught with the potential for errors. BIM greatly increases the ability to detect system clashes and conflicts during design review by allowing integration of all key systems into the model. This allows conflict checking to occur rapidly and accurately in three-dimensional visualization, before construction begins.

The dramatic difference between BIM and traditional methods for clash detection was illustrated in a 2005 federal courthouse project in Jackson, Mississippi, conducted as a BIM pilot project by the federal General Services Administration. Before construction began, an independent review team used two different methods to analyze the designs for constructability issues and system conflicts. One review was performed using a three-dimensional BIM model and the other was done using traditional two-dimensional drawings. The BIM model reviewers found 257 constructability issues and 7,213 conflicts. The traditional plan reviewers found six constructability issues and one conflict.

Take-offs and Estimating: To determine a project's construction cost, contractors traditionally perform material "take-offs" manually, a process fraught with the potential for error. With BIM, the model includes information, or can link to information, which allows a contractor to accurately and rapidly generate an array of essential estimating information, such as materials quantities and costs, size and area estimates, and productivity projections. As changes are made, estimating information automatically adjusts, allowing greater contractor productivity.

Shop and Fabrication Drawings: Under traditional design practices, fabricators of building components or systems must review the plans and specifications and prepare fabrication drawings which must be approved by the design team before fabrication can begin. This time-consuming process is laden with the risk of errors which, when discovered in the field, inevitably cause delays, increased costs and claims.

BIM models significantly reduce the risk of fabrication errors because conflicts can be resolved through the model. Also, because BIM can provide accurate construction details, the models can reduce fabrication costs by limiting the fabricator's detailing effort and providing greater assurance that prefabricated components will fit in the field. As a result, more construction work can be performed offsite in controlled factory conditions and then efficiently installed at the site.

Energy Efficiency and Building Life Cycle Management: BIM models are being used to model and evaluate energy efficiency, monitor a building's life cycle costs and optimize facilities management. BIM allows the owner to evaluate upgrades for cost-effectiveness, and provides an accurate as-built model for operations and maintenance throughout a building's life cycle.

BIM promises to exponentially improve design and construction. BIM allows design optimization, fewer construction errors; fewer design coordination issues, and thus, fewer claims. Contractors benefit through less coordination and engineering effort, reduced fabrication costs and more accurate costing data. Owners can use the model to improve management and operation of the facility. In short, BIM offers the promise to actually accomplish what the construction industry has always sought to achieve — increased productivity coupled with decreased costs, shorter project delivery times and fewer disputes.

Despite BIM's vast potential, its widespread adoption faces significant obstacles.

There is a wide spectrum of possible uses of BIM on construction projects. At one extreme, architects and engineers can use BIM simply to produce better quality design documents without providing the digital model to any other party. Contractors separately can create models for estimating, fabricating or simulating construction without sharing the models. Used in these limited ways, BIM does not come close to realizing its powerful potential. At the other end of the spectrum, BIM can provide a collaborative framework among all project parties, allowing the free flow of data about what is being designed and how it will be constructed. The collaborative use of BIM takes full advantage of BIM's capabilities.

However, the collaborative use of BIM also fundamentally alters traditional construction project relationships and presents new risks and issues.

Designer Liability Exposure: In a collaborative BIM setting, many parties contribute to the design. Crucial details embedded in the design may be provided not by licensed design professionals, but by specialty subcontractors or vendors. In addition, BIM software is designed to react to changes in the model, by modifying elements of the design affected by a change. Moreover, BIM software "knows" the building codes and applicable engineering principles and applies that information to the model.

These circumstances increase the potential liability exposure of design professionals who use BIM collaboratively. Under the law in all states, the architect or engineer of record must be in "responsible charge" of the design, meaning that the designer either must perform or directly supervise performance of the work. The plans are sealed by the responsible professional to signify compliance with this requirement and acceptance of the associated responsibility. Based upon these traditional legal principles, the designer is responsible for the entire design produced by BIM, even though crucial elements may have been provided by others or by the BIM software itself. This enhanced liability exposure of design professionals is a disincentive to the widespread, collaborative use of BIM.

Different BIM Models: Ideally, a construction project would utilize a single BIM model which is used by the designers, contractors, subcontractors and fabricators for all purposes. Each party could access the model at will, adding content that all others could immediately utilize. The reality is that there rarely will be a single BIM on a complex project. The architect may have its design model, each engineer may have an analysis model for its discipline, the contractor may have a construction simulation model and the fabricator its shop drawing or fabrication model.

Interoperability — the sharing of information between these different models — is critical to the collaborative use of BIM, by assuring that each model consistently represents the same building. However, current technology does not yet allow seamless coordination between different BIM applications. The use of multiple models undermines the collaborative use of BIM and prevents project parties from reaping the full benefits of BIM's capabilities.

Because BIM's benefits are so compelling, it is inevitable that, over the next several years, its use will become nearly universal. BIM is transforming how buildings are designed and built, and redefining the traditional roles of designers, contractors, subcontractors and fabricators. With its great promise of increased productivity, decreased costs, shorter delivery times and fewer disputes, all through true project party collaboration, BIM is destined to soon become the standard practice for all design and construction. ■