Practical BIM

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How are engineers and architects implementing and using this developing technology?

BUILDING INFORMATION MODELING CONTINUES TO BE A BUZZ WORD IN THE INDUSTRY. But how are engineers and architects implementing and using this developing technology? And what benefits does it deliver to the document preparation process and to the project itself?

To answer these questions, let's take a brief look at the document process itself and how it has evolved. The building consultant team, composed of architects and engineers, typically strives to produce complete contract documents, which usually take the form of two-dimensional paper documents. On typical projects each consultant produces their own set of documents associated with their respective trade. The contract documents reflect the design and engineering plus the results of an extensive coordination process between consultants.

The design team strives to provide economically efficient designs within the project constraints and fully coordinated amongst all the consultants. The coordination process takes place continuously via an exchange of preliminary documents between consultants, culminating in a final package that hopefully reflects and considers the final design of all the team members. Complex projects such as hospitals, stadiums, concert halls, and major high-rise towers require significant effort in coordination to achieve the project goals. A poorly coordinated project results when consultant coordination efforts are not kept up to date with the final design or engineering conclusions of the entire consultant team.

Until recently the dominant software used by architects and engineers in the development of project documents for building structures was AutoCAD. Although AutoCAD has a variety of three-dimensional drawing tools, it has been used primarily as a 2D drawing device. As such, AutoCAD has greatly expedited the process of drawing production and significantly improved the accuracy of drawings over hand methods, which are basically extinct at this time.

However, AutoCAD documents have their limitations, primarily in that they are not "intelligent" documents. Intelligent documents store information about the building systems and/or components. For example, a beam as drawn on a 2D AutoCAD document would be symbolized as a single line. The beam size information would be shown in text adjacent to the drawn line. Internally, within the computer memory, no information about the beam is known or compiled.

In contrast, an intelligent document can also present 2D drawings and can show the beam as a single line, with the beam size information adjacent to the drawn line. However, this is where the similarities end. The intelligent document internally saves the structural information associated with the drawn beam—the beam size, length, weight, and other relevant information including all the 3D properties. As a result a full 3D picture can be created, if desired. Consequently, an intelligent drawing of the structural, building system, and architectural components would have the ability to draw the full 3D representation of the building. In addition, since the actual geometric properties are available, areas where building components clash can be picked up by the software. Intelligent documents have the ability to provide material quantity data for the project. Relative to the structural components, the project tonnage, piece count, and material types can be tracked continuously through the document preparation phase, thereby aiding the budgeting process.

The combined integration of the full architectural, building system, and structural components into one BIM database for the project is typically not being done for most projects at this time. Although a valuable feature, most consultant teams involved with conventional building types have not developed the knowledge and sophistication to implement this feature on such a global scale.

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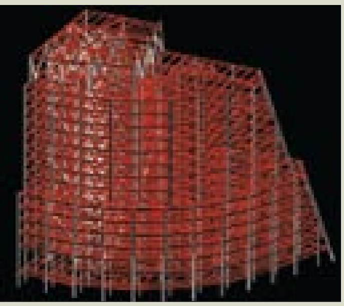
Current Practice

What used to be a tedious computational method working with 2D segments of a building is partially becoming a visual process working with pictorial representations of the structure, building systems, and architecture. Although this new process is taking shape, it is far from being fully implemented in the current building design practice. Many architects and design professionals are now implementing one or more of the available BIM software packages. But there is a significant learning curve associated with any BIM package. Consequently, as architects implement BIM they are usually beginning solely with the architectural components and perfecting their use of BIM before requiring it of the entire design team. It has become somewhat common to implement the structural components within the BIM model prior to incorporating building systems.

At WSP Cantor Seinuk, we have been using intelligent modeling of structures on a select basis for over 10 years. Although expensive to implement, and not seeing initial use by the architects or mechanical engineers, we found intelligent modeling a very beneficial drafting and coordination tool. For example, with our initial foray into the world of BIM, our plans showed all beam framing as double lines, thereby conveying the true width of beams and girders. Coordination around the building core areas was greatly improved. Elevations of bracing systems were easily coordinated with corridors, doorways, core walls, and ceilings. The structural plans also reflected the actual column sizes as compared

Citigroup's "Court Square Two" Office Building
Queens, New York

As the structural engineer for this project, WSP Cantor Seinuk decided early on that developing a full three-dimensional model of the steel framing would be beneficial. At the time, we had been using a program called ProSteel for four years and chose to continue with it for this project. The full 3D structural model was developed and continued to grow with the respective phases of the project. Conventional paper documents were issued at every phase during project development. However, internally the 3D model was utilized to present and coordinate the complex areas of the project. Since the architect was not using ProSteel, but instead was working with conventional AutoCAD, we issued AutoCAD-compatible information that was exported from the ProSteel model. The exported files were overlain on top of the AutoCAD drawing in order to coordinate the structure and architecture. Coordination with the building systems was done via conventional methods, with the exception that ProSteel shows active member widths and depths in 2D plans and bracing elevations.



Courtesy of WSP Cantor Seinuk

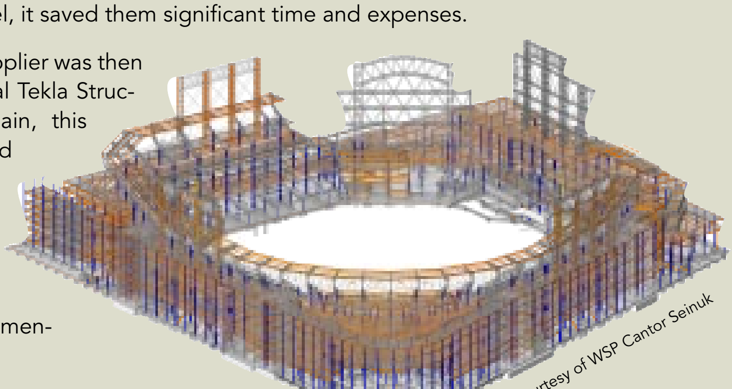
During the later stages of the construction documents phase, we began preparing a Tekla Structures (then X-steel) model of the structure. The Tekla Structures model was prepared via a combination of exported information from the ProSteel model and conventional hand input. This resulting model proved to be highly beneficial. First and foremost it formed the basis of the bidding documents; all steel bidders were given the Tekla Structures file, and the tonnage and piece count was as defined in the Tekla Structures model. The feedback from the bidders was very positive, and they confirmed that this process expedited the bidding. In addition, upon the steel contract being awarded, the selected steel fabricator used the provided model and claimed the process was extremely helpful, saving them one month of work.

New York Mets Stadium—Citi Field
Queens, New York

For this project, WSP Cantor Seinuk decided to use Revit, the newest BIM software from AutoDesk. The architect, HOK Sport, took full advantage of the 3D modeling features in Revit and the compatibility between both AutoDesk products. They combined both models into one and performed the structural and architectural coordination using the 3D features. Considering the highly complex nature of the stadium, 3D overlay and coordination was a necessity—especially considering the highly fast-track nature of the project.

When it came to the bidding and construction phase of the project, WSP Cantor Seinuk prepared a Tekla Structures model for use by the steel bidders. Preparing the model from the Revit 3D model was a relatively smooth process. The Revit structure was exported into Tekla Structures, and the feedback from all the bidders was extremely positive. In addition, as we issued addendums to the bidders working with the completed Tekla Structures model, it saved them significant time and expenses.

The selected steel supplier was then provided with the final Tekla Structures model and again, this enabled an expedited shop drawing process to proceed—without waiting for the model creation and without the delay of numerous dimensional RFIs.



Courtesy of WSP Cantor Seinuk

to a generic one-size-fits-all picture. Overlays with architectural finishes, walls, and façade elements became possible.

Although not common yet, we are now beginning to see collaborative coordination efforts that use a single 3D model where the structure and architecture is shown in the same model. In complex geometric building shapes, working with intelligent 3D models is imperative. This is especially true in stadiums and other non-orthogonal structures.

Communication with Contractors

Working with BIM software tools has opened up new methods of communication with contractors and subcontractors that were unheard of just a few years ago.

Within the steel industry the vast majority of fabricators and detailers use 3D detailing software for the preparation of steel shop drawings. As a result of an AISC initiative a few years ago, a digital standard for electronic communication, CIS/2, was established. Consequently, the primary detailing software packages have a unified standard for electronic transfer of data, and the structural steel framework that was developed and presented in one of the primary BIM software packages can be exported into the steel detailing packages.

This method of data transfer has now become commonplace for steel-framed structures and has resulted in significant time savings. A typical project scenario would entail the following process: At the final stages of completion of the construction document, the conversion process of our BIM model into one of the primary steel detailing software formats would commence, either the Tekla Structures (formerly X-steel) format or the SDS-2 format. The steel bid documents would include the paper documents and the digital model. Providing the digital model in one of these two formats enables the steel bidders to avoid the time-consuming process of recreating the building digital model. By using the model provided to them, the time for the bidding process is shortened significantly, and there is uniformity in the bids. The confusion of bidders presenting differing steel tonnages is eliminated; the digital model clearly defines the piece count and tonnage. The only variation in material quantities is the allocation to connections, and with this process owners can clearly see the tonnage associated with connection material. Furthermore, changes to the steel structure for bid alternates and updates are easily communicated via changes to the digital model.

Finally, upon project award, the updated detailing model in either Tekla Structures or SDS-2 format is provided. Shop drawing creation begins immediately with no lag time for model preparation. Upon a recently completed WSP project in New York, the steel fabricator stated that this process easily reduced the shop drawing process by one month, facilitating the early start of steel fabrication and erection.

We have also found that providing the digital model to the detailers significantly reduced the dimensional RFIs, which often plague the shop drawing review process. The dimensional gaps that usually occur upon paper documents are nearly eliminated on digital documents unless deliberately included.

Although the benefits of BIM are many, there are drawbacks and challenges to overcome:

- BIM standards are not fully defined. The multiple BIM products do not have the ability to communicate with one another.
- New methods of team collaboration require new definitions for individual responsibility and liability.
- Legal ownership of collaborative digital models must be defined.
- Increased dimensional responsibility for the design team results in additional legal liability.
- Expedited processes reduce the time for the customary process of "checks and balances."
- How does the new BIM process change financial compensation for the design team?

It's a new world out there when it comes to BIM. We are only in the infancy stage of development and usage. Much remains to be developed and defined. As with everything else in the free market world, time and market conditions will determine the general direction and final form. It's up to the innovative design professionals, engineers, and architects to test and implement these new products. And it's up to the owners and developers to encourage their consultants to pursue and utilize these new techniques and products. MSC

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