The Importance of BIM in Structural Engineering

The Greatest Change in Over a Century

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Building Information Modeling (BIM) is a building design method that uses a database of coordinated, graphically rich, internally consistent, computable information in three-dimensional models for design, engineering, construction and facility management. In varying ways, in less than ten years, BIM will permanently change the structural engineering profession and its universities, firms, clients, markets, design codes, digital tools, contracts, insurance policies, global recruitment of staff, work process and many other aspects. The evidence suggests that those who do not take a reasonably sober view of this disruptive technology will have a hard time recognizing the typical structural engineering firm of 2015.

Such bold claims of the importance of BIM may appear to be overstated and warrant some justification.

What Is BIM and How Is It Important?

Before proceeding too far, a more detailed working definition of BIM is important. At the heart of BIM is the concept of each member of the building process having its own digital relational database for its scope of work that can 'talk' to the others' databases in a process known as electronic data interchange (EDI). An example of this concept is seen in ordering a book online as compared to ordering one through the mail. A little over a decade ago, you would find the book you wanted in a paper catalog and place the order over the phone, or fax or mail an order form. After a few days of processing the order manually, the shipper would send your order and you would hopefully receive your book. All through this process, the stakeholders – including the purchaser, shipper, reseller, publisher, warehouse and purchaser's bank – transferred data manually. Today, when a book is purchased online at some of the most popular sites, all of the stakeholders have their own separate databases that can communicate digitally via EDI with different companies at different locations in seconds (*Figure 1*).

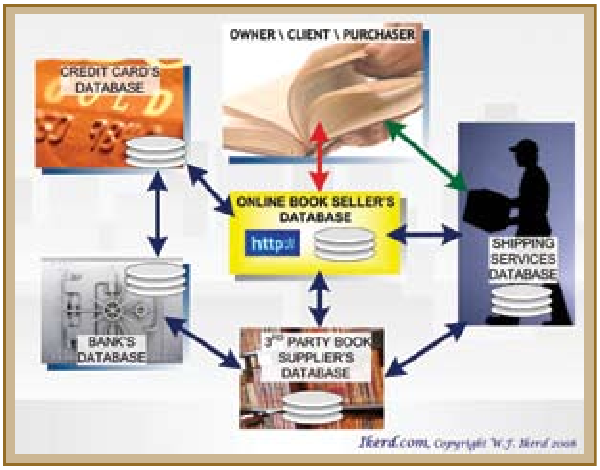

Figure 1: Today when a book is purchased online at some of the most popular sites, all of the stakeholders have databases that can communicate digitally via Electronic Date Interchange (EDI) with different companies at different locations in seconds.

The building industry – consisting of architects, engineers, contractors and owners (A/E/C/O) – has historically transferred data in manual ways with paper, phone, fax, mail and e-mailed print documents. Today, with BIM using EDI, new business processes are being created that allow electronic data interchange among all of the A/E/C/O stakeholders (*Figure 2*). It is true that there are many challenges to smooth data transfer among the different stakeholders on a building project today. However, these issues are being addressed at a rapid pace that can be measured in months and years, rather than decades.

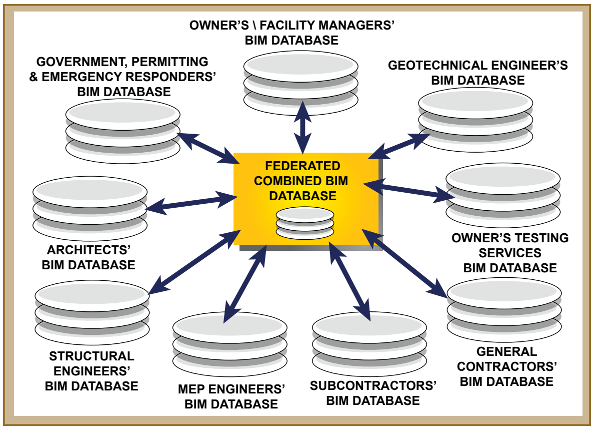

Figure 2: Today with BIM, new business processes are being created that allow Electronic Data Interchange (EDI) among all of the A/E/C/O stakeholders. Rapid digital information flows will create new business models, challenges, and opportunities for all of the parties involved.

As a point of reference, when assessing the importance of BIM in structural engineering, consider the history of change in our profession since the industrial revolution in contrast to the potential changes from BIM. There are only a handful of singular events that permanently altered the structural engineering profession. Example events include the Bessemer process for mass producing affordable steel, the first commercial electric welding machines, prestressed concrete, the personal computer and the Internet. All of these events fundamentally changed the structural engineering profession in one or more of the following seven areas: (1) design codes, (2) engineering work processes, (3) building structure possibilities, (4) clients, (5) staff, (6) marketing, and (7) business practices including risk and liability issues. BIM has the potential to create even more profound effects on the structural engineering profession.

Why BIM Is Happening Now

There are three essential converging elements required for an industry to convert to using three-dimensional, object-based models like BIM: computer power, a common database platform, and network bandwidth. In the past, when industries such as aerospace, automotive, and manufacturing could afford these three essential requirements, they converted to an object-based modeling method. The structural engineering profession is poised for BIM because the identified criteria are available

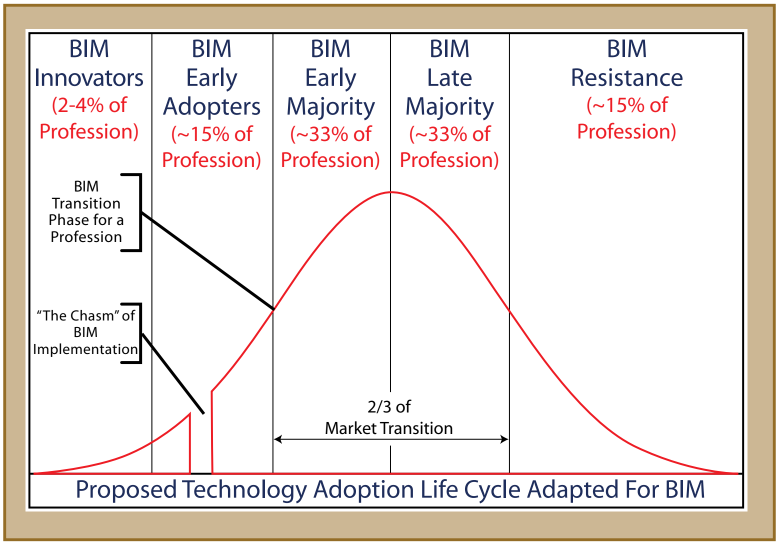

Figure 3: Author's application of BIM with classic adoption life cycle model of new technology. In light of the national survey of structural engineers, the profession is poised for the early majority and some of the late majority to transition to BIM in the next 2 years. The chasm represents the initial challenges of change.

and finally are considered economically "within reach" by the building and construction design community.

If BIM adoption is similar to most other innovations, it will follow the classic technology adoption life-cycle model originaly developed in the 1950s (*Figure 3*). BIM implementation, as a market-driven technology, has the potential to grow as rapidly as the Internet did, starting in the mid-1990's. The speed of adoption is an important aspect of BIM that will surprise those structural engineers who have viewed it with denial or extreme skepticism (*Figure 4*).

The author believes that the transition to BIM for the structural engineering profession in building design will historically be viewed as a period that substantially took place during the decade leading up to 2015. Possible rates of BIM adoption are a topic of particular importance to the structural engineering profession when considering the relatively short time frame allowed for firms to adjust to the seven key areas affected.

The face of the current structural engineering office needs to be put in perspective to understand the importance of BIM in the seven areas identified. A recent survey, conducted earlier this year for structural engineers in a joint effort by the SEI-CASE Joint Committee on BIM and the Structural Engineers Association of Texas (SEAoT) IT Committee on BIM, provides insight into this topic. Based on this survey, the majority of offices have a staff of two to twenty people. Most of the staff is under the age of 40. The majority responded that BIM training time would cost "4-6 weeks (160-240 hours)" of lost billable time per person in the first year of implementation. Nearly two-thirds of structural engineers in the survey responded that they would need to use BIM in the next 12 to 24 months, with over 30% saying "NOW".

Work Process, Business Practices, and Types of Structures

Three areas of the profession that BIM will affect are in work processes, business practices and the types of structures that are designed. Work process will be affected internally by having engineers and drafters collaborating in the same model. Additionally, the work process with clients, such as architects who also model in BIM, may be challenged by requiring them to speak to drafters when their question relates to BIM and structural engineers when it relates to design intent. Firms that have the traditional engineering and drafting department dichotomy may find it necessary to take their drafters who work in BIM with them to kick-off meetings, even for what they might consider small projects. An alternate emerging work process for firms is to have their graduate structural engineers involved early on in the modeling process.

Another work process that will be changed will be the way in which we review shop drawings with BIM. In the near future, it will not be uncommon to receive the detailer's model along with the paper shop drawings for structural engineers to use as a tool in organizing and recording their comments. Use of such modeling review and commenting tools may actually reduce the engineer's time and effort in reviewing shop drawings, and could (more importantly) reduce the overall fabrication process for owners by allowing fabricators to receive the engineer's comments in digital models.

All of the changes in work process also directly affect business practice. The business goal is for BIM to reduce the overall effort of structural engineers on a given project for a given fee. However, when considering the BIM effects on business practice, the proportion of effort on a project may not be distributed along traditional percentages. It is very likely that more effort is required early on in a project to set up BIM than we would have had with CAD. This initial setup cost of BIM is not a problem when the overall effort at the end of the project is under budget. However, if the project is placed on hold, firms stand the risk of having their effort be far more than their contractual earned fee.

BIM will also affect contracts by creating a need to define how the models are used and who owns the models. Firms will also need to review their business practices with their insurance providers regarding their use of BIM in construction and how to address any new risks that BIM poses when working in integrated teams.

The large learning curve associated with BIM could make the first group of BIM projects unprofitable, as is common with any technology change. Also, BIM can give a false sense of accuracy when items are easily modeled incorrectly with great precision and with high levels of detail. Software companies are currently pushing new BIM work flows for structural engineers, and owners, architects, contractors, subcontractors, building officials and governments are just beginning to develop momentum that will change the profession's business practices.

BIM will also lead to an evolution in structural building types that can leverage the advantages in scheduling and fabricating from BIM. As the BIM era develops, we will see an emerging emphasis on unitized building components such as curtain wall, steel and precast concrete that can be fabricated and assembled offsite in shops from the BIM with computer controlled equipment. The contractor will also use BIM to coordinate the components for "just-in-time" delivery and installation without significant site storage and handling.

Staff, Clients and Marketing

BIM will change the way that structural engineering professionals relate to staff and clients. A significant change related to staff is the cost of training. This is a very expensive proposition for the majority of firms that are twenty people or less. Funding this training takes investment and a high level of commitment by upper management. The most expensive aspect of BIM for firms could be the tendency for some to change firms with their newly found BIM skills as a way to advance in their careers, even at the expense of the current employer's training investment. Any staff that is trained in BIM will be in high demand over the next few years. However, when trying to hire top talent, the firms that do invest in BIM training will have a marketing edge on hiring given the high personal interest of BIM among structural engineers, with nearly two thirds rating their interest in BIM as "above average" to "very high/exceptional".

An unintended consequence of BIM related to staff is that, for the first time, we see a framework for combining much of the structural engineering information for all aspects of a project in one digital relational database. Thomas Friedman, in his books *The Lexus and the Olive Tree* (1999) and *The World Is Flat* (2005), pointed out that professions that organize their data in digital relational databases will very soon begin outsourcing notable portions of their work. This is especially the case in professions with a shortage of local staff. Friedman documents examples from other professions, which could be easily paralleled in certain segments of the structural engineering profession. A noteworthy example of globalization is the case where digital MRI's of the human brain are sent to medical doctors overseas for interpretations and mapping, and then are returned to the US in less than 24 hours. Freidman also points out that since the early 2000s, the accounting profession has sent hundreds of thousands of tax returns to India for processing overseen by CPA's licensed in the states. Could BIM be the packaging of our data that facilitates remote engineering of portions of the US structural engineering profession?

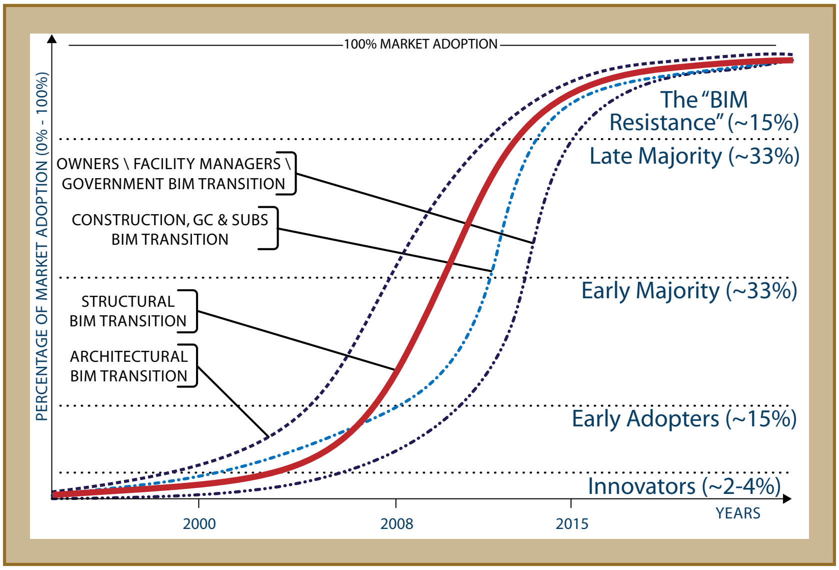

Figure 4: Author's projections of the technology adoption of BIM for the stakeholder in the project delivery process. Projections are based on the national survey referenced in this article, author's experience, and history of other technology transitions.

Client relationships and the way structural firms market to clients will also be changed with BIM. Traditional longstanding relationships with clients who are committed to BIM will be challenged by structural firms that resist investing in the new technology. BIM-resistant structural firms will find themselves aligned more with clients who are not aggressively adopting BIM. Similarly, structural firms that have made the investment and commitment to BIM will find opportunities with new clients who are interested in BIM.

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Building Codes and Owner Requirements

Building codes are another area that illustrates the importance of BIM in the structural engineering profession. Many structural engineers will remember the regional effects on design when the International Code Council's (ICC) new International Building Codes (IBC) were adopted in their local municipalities, sometimes resulting in seismic lateral loads controlling designs in areas that were previously considered non-seismic. Whether structural firms like doing seismic analysis or not, they now have to be in compliance with the newly adopted IBC codes.

The ICC has been working for over two years in developing the SMARTcodes initiative with BIM to make "automatic code checking" possible. The SMARTcodes are a part of ICC's vision for the future of e-government environments where models can be code-checked and then processed electronically for permitting. Even structural firms that want to avoid BIM may find themselves investing in the code-required BIM process, just as they did with code-required seismic design, when their clients are working in municipalities that adopt BIM-based plan submitting and permitting.

Globally, this has been seen in the building industry within the last three years in several areas. The governments of Norway and Singapore require the use of 3D object-based BIM for plan submission and review. Similarly, in Finland, Senate Properties, a company that works closely with government agencies, has decided to require BIM for its projects as of October 2007. Closer to home, the U.S. Coast Guard and the General Services Administration have adopted BIM requirements at various stages of their projects. In 2006, the Associated General Contractors (AGC) issued *A Contractors Guide to BIM*, and in 2007, the first part of the National BIM Standard draft was published, giving guidance for owners regarding what to require in BIM. The American Institute of Steel Construction (AISC) has been working since 1998 on developing an open standard computer language called CIS/2 that facilitates EDI, which was noted in the 2005 update to the AISC code of standard practice. This effort has resulted in many well-documented successes with structural steel models that have passed through into construction. Furthermore, private-sector clients, such a General Motors, have mandated that BIM be used on all of their future facility construction projects. In these cases, structural engineers have no choice but to invest in BIM if they want to work with their clients who require it.

The Future

No one can guarantee what tomorrow holds for BIM. However, good stewardship of our individual careers, our firms' futures, our clients' best interest and our profession warrant structural engineers to be actively involved in the development of BIM. Support and participation in groups such as the SEI-CASE joint committee on BIM or the SEAoT IT Committee on BIM are excellent opportunities for engineers to become involved in this important process. The significance of BIM is that it is a powerful paradigm shift that will permanently change almost all aspects of the structural engineering profession in less than ten years. It provides a rewarding opportunity for those who can develop strategies to overcome the challenges that BIM poses.▪

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