White Paper

Integrated Practice and BIM

Ryan E. Smith, Integrated Technology in Architecture Center, University of Utah

The construction industry is inefficient, fraught with errors and litigation. Traditional contracts rigidly delineate responsibilities with much elaboration on the consequences of failure. These contracts reinforce risk-abating behavior, causing project teams to not engage in integrated practice models much to the disadvantage of all stakeholders. Owners are loosing money on projects, architects are not seeing the quality of design increase, and contractors are bearing a great deal of financial burden and risk in the process. In addition to risk exposure, there is too little investment and training in technology, including innovation in the form of collaborative delivery approaches fostered by more flexible and responsive contracts and BIM integration into the design and construction delivery process.

Premise

The U.S. Labor and Statistics Bureau estimated U.S. construction expenditure in 2008 at 1.3 trillion dollars. This figure doubles the expenditure of next closest country, Japan who spent 600 billion dollars. With construction being a large portion of the gross national product, the lack of investment in productivity and innovation is staggering. (Fig.1) This is not a new problem. In 1996 The Construction Industry Institute wrote:

“The U.S. construction industry, contributing over $847 billion annually to the U.S. Gross National Product is experiencing competitive pressures which have squeezed margins to historic lows. The construction industry now ranks as the second worst performing industry in terms of return on investment – only the airline industry rates poorer. Intense competition has forced companies to seek any avenue to preserve profits, and when such is threatened, to aggressively seek to recover losses through litigation. This business climate has led to adversarial relations which greatly hinder the construction process.”

![Figure 1: U.S. Labor and Statistics Report 2008 – construction expenditure by country](image-url)
Paul Teicholz at the Center for Integrated Facility Engineering (CIFE), Stanford University, in 2007 calculated the productivity within the U.S. field construction industry relative to all non-farm industries from 1964 through 2004. (Fig. 2) Teicholz developed this data by dividing contract dollars from the Department of Commerce by field man ours of labor for those contracts from data at the Bureau of Labor and Statistics. The contracts include soft (design costs) and hard (construction costs including: materials, delivery, and labor). During this 40-year period U.S. productivity outside of construction has doubled while labor productivity within the construction industry is estimated to be 10% less than what it was in 1964. Labor historically represents 40-60% of construction’s estimated costs. Owners are therefore actually paying 5% more in 2004 than they would have paid for the same building in 1964. This would seem to make sense because buildings are much more complex from a systems and performance perspective today than they ever have been, however other industries harnessing integrated processes and digital technology have produced lower labor cost with increased quality. This statistically is not the case with construction.

Likewise, Horman and Kenley report that across a variety of circumstances and contexts, 49.6% of construction operative time is devoted to wasteful activities. Eastman et al state,

“Conceptually, during the lifecycle of a construction project, a project team is responsible for transforming labor and material into a building. In other words, design and construction can be viewed as a series of activities, where some add value and others do not. There are numerous time-consuming, non-value-adding activities in the design process, such as correction of errors and rework, the physical handling and organization of documents, and transportation, inspection, and movement during the construction process.”
The Construction Users Round Table (CURT) is an organization that is made up of some of the largest companies that build on a frequent basis recently published ‘Key Agents of Change’ that indicated that lean needs to become the new culture in the industry and that this requires a shift in everyone’s thinking. In these efforts, CURT has redefined lean construction as lean project delivery to emphasize that the principles of lean are not just about construction or even its precedent in manufacturing, but about the entirety of the building industry including architects and engineers. This paradigm shift is to:

a. integrate the design and construction delivery process holistically to encourage new methods of contracts including integrated project delivery;

b. encourage advances in the development and employment of digital communication tools such as BIM.

**Integrated Project Delivery**

In 2007 and 2008, two industry organizations published contracts that take the desirable elements of both design build’s speed, and information sharing, and performance contracts that emphasize outcomes via shared risk and incentives. In 2008 The American Institute of Architects (AIA) published two separate Integrated Project Delivery (IPD) families: the so-called transitional AIA A295, built on a construction management at risk model, and the Single Purpose Entity (SPE) family, developed as the contract embodiment of the principles espoused in Integrated Project Delivery: A Guide, published by the AIA in 2007. ConsensusDOCS emerged before the IPD families with its Standard Form of Tri-Party Agreement for Collaborative Project Delivery, more commonly referred to as ConsensusDOCS 300, published in 2007. The clear difference between ConsensusDOCS, IPD contracts and the traditional DBB delivery is the concept of "relational contracting." This can be explained as contracts where parties create an organization and agree to risk share with collaborative and collective decision-making. (Fig.3)
Fostering a collective decision-making will allow project teams to communicate more freely with information than has been possible before. This will allow for construction information to be shared across discipline lines. For example, traditional contracts do now allow for architects to share their digital information directly with contractor or subcontractors. This does not benefit an integrated delivery of products because fabricators must develop their own shop drawings and the get submittal approval. The future of practice facilitated by IPD contracts should allow for free information sharing so that the design information can transition into shop information.

The SPE family also developed by the AIA bears no resemblance of traditional contracts. The AIA has been quoted as saying that it developed this model from product design and production deliveries such as the automotive industry that holds a DB to produce a product through a combination of its own forces and independent contractors. Effectively, the project players under SPE become a limited liability company. Although all are under one entity, project players, such as the architect, may receive reimbursement for the costs they incur and may earn profit through performance. Providing incentives during the construction process provides motivation for architects, engineers, contractors and fabricators to work collaboratively so all benefit. If one earns a profit, all earn a profit. Likewise, the team agrees to indemnify one another in the event of litigation, causing all disputes to be resolved outside of the courtroom.

Few project have been run under any of these contracts. As case studies become more prevalent, the pros and cons of each contract will become more transparent. In a recent AIA Utah meeting Craig Coburn, a lawyer in Salt Lake City discussed the potential pitfalls of this delivery method, but agreed that he sees great benefits for all project stakeholders. In the interim, IPD provides more work for lawyers than less as an entire industry relearns its relationships to one another and breaks down the prejudices of the disciplines.

Building Information Modeling (BIM)

While BIM has existed in some form for at least 20 years, it has emerged as a major topic in the AEC industry in the past decade, due to a confluence of factors including the growing dissatisfaction among project owners with the cost of delays and change orders typical in construction projects. The Construction Users’ Roundtable (CURT) issued a white paper in 2002 documenting the financial costs of poor coordination in construction documents and faulty communications among the members of a project team. The paper called for dramatically increased collaboration among the participants in construction projects, both of which BIM augmented to facilitate. This movement received considerable impetus when the General Services Administration mandated that all Final Concept Approvals (roughly schematic design) include a BIM spatial model starting in FY 2007. Another major factor in the recent emergence of BIM is that the technology itself has significantly matured. This has in turn led to several developments: pioneering projects by architects like Frank Gehry using BIM to create buildings that would otherwise be prohibitively complex, demand by architects for BIM tools responding to initiatives like GSA’s and the efforts of software developers to make BIM tools more useful.

Enhanced continuity is at the heart of the rationale for adopting BIM in the AEC industry. Used in one sector alone it can enhance that part of the process: architects can increase their productivity, contractors can shorten construction times and reduce waste, owners can manage their properties more easily. The traditional system in the AEC industry operates on the basis of separate pools of information cautiously shared among owners, designers and constructors. Everyone is aware of the inefficiencies this system creates and clamors for greater collaboration within project teams. A crucial component of a more collaborative system is a means of effectively accumulating and incorporating an enormous amount and variety of information over the course of a project. BIM allows for increased information sharing. (Fig. 4)
Architects also stand to gain a great deal from a more collaborative environment. Architects essentially create, gather and organize information in their work. The value of their work (and their role in the overall construction process) depends on the extent to which the other participants in the building process rely upon that information. Under the current process, the information contained in a set of drawings and specifications falls far short of what is required to actually build a building. Contractors, fabricators, vendors and others must add an enormous amount of information to that which they receive from the designers in order to actually construct a building. The two largest categories are constructability information and details contained in shop drawings and other submittals. If the information added by constructors were available during the design phase, architects would be in a position to incorporate it in their designs rather than scrambling to respond to it as they do now.

**AEC Productivity**

Arguably, the largest benefit of BIM is in productivity gains. The traditional distribution effort for architects for example according to the AIA B-151 is 15% for schematic design, 30% for design development, and 55% for construction documents. This distribution is proportional to the amount of effort required for the design team’s services. Utilizing BIM technology a reduction in time required to produce detailed construction documents is realized. If this timesavings can be shifted to the front of the process in pre-design and schematic design to allow for project players in an integrated fashion to make decisions regarding function, form and most important to productivity, prefabrication and construction methods, this will not only save time in design delivery, but also in the delivery of construction. Linking the BIM model to manufacturing allows this process to be even more streamlined. This shift in operations however will require project players to front load the design process as previously discussed and therefore, shift their traditional billing cycles in a project. With the many projects that do not extend beyond development, this billing method will benefit all parties involved to come closer to realizing the project in the end. (Fig. 5)
Figure 5: The “MacLeamy Curve” illustrates the concept of making design decisions earlier in the project when opportunity to influence positive outcomes is maximized and the cost of changes minimized, especially as regards the designer and design consultant roles.

Some architecture and engineering firms have begun to put BIM to use to improve project delivery. Ghafari Associates in Dearborn, MI has designed several projects for General Motors that feature a virtual model of the project so complete that contractors rely on it to fabricate every piece of the building off-site. In an engine plant in Flint, a 442,000 SF addition, construction was finished 5 weeks ahead of an aggressive schedule and there were no change orders due to site conflicts. Despite the fact that such projects are driven by purely technical considerations and have comparatively simple requirements, they prove that BIM can have a significant impact on project delivery and that the goal of a complete BIM model can be achieved and put to use in the real world.

Linking time to the three dimensional information, simulation of construction process can anticipate what challenges will arise during construction on a day-by-day schedule. 2D paper documents do not allow for this kind of analysis. BIM tools have the potential to interface with automation equipment, such as CAD/CAM shop methods. Because the model represents accurately the objects properties for fabrication, CNC facilitates tooling to precise dimensions. BIM has great potential to allow multiple manufacturers and fabricators to produce objects in their shop simultaneously and then deliver and assemble on site seamlessly because of the dimensional accuracy of the model and fabrication equipment. Boeing has used this model of delivery dealing section chunks of the plane from various suppliers that are then assembled in their factory. This has obvious benefits to reduce cost and construction time as workflows can overlap. (Fig.6)
Figure 6: The project flow from pre-design to closeout in an integrated delivery is different from traditional in that it does not use the conventions of SD, DD, CD that tend to create workflow barriers. These phases of a traditional design process do not encourage collaboration. IPD suggests the identification of project goals early so that decisions regarding production methods are considered from the beginning. The ‘what’, ‘who’, and ‘how’ are integral to the design process and involve not only owner and architect, but also contractor and key subcontractors such as prefabricators that will have a major stake in the project delivery. In an integrated delivery documents are simply an extension of early decisions regarding ‘how’ shortening in the overall time of design delivery. In a prefabrication project they may take the form of bridging documents, allowing the fabricator to develop elements of package for construction. Early participation of regulatory agencies, subcontractors, and fabricators allows shortening of the Agency review and Buyout phases.

In order to harness BIM for manufacture and prefabrication, construction level information must be included in the model. This has recently occurred in two ways:

- The building model is a detailed design expressing the intent of the designer and the client. The contracts are expected to develop their own independent construction model and documents including shop drawings and submittals from subcontractors.

- The building model is a detailed design the will be further detailed for he use of all aspects of construction, planning, and fabrication. In this method, the design model is a starting point for elaboration of the construction team.

The first method is very similar to how traditional construction delivery occurs in a DBB contract structure. This is seen by architects to be an alleviation of risk and liability during construction process. The AIA B151 states that drawings delivered by design teams for construction are intent only. The transfer of liability then after bidding is to the contractor. This has required contractors
and their subcontractors, including prefabricators to develop all submissions from scratch. Marrying the design intent from the design team with the drawings necessary for fabrication results in many rounds of submissions, communication, and more often than not, mistakes on the job site assembly. This processes based solely on design intent according to Eastman et al is “inherently inefficient and irresponsible to clients.” Designers can provide BIM model information to fabricators and detailers and allow them to elaborate the design information as needed to both maintain the design intent and refine the design for fabrication. \[xiii\]

BIM models allow for quantity take offs. The elements are included in the design model, facilitating the quantities, specifications and properties that can be used to procure materials from the various prefabricators. As Eastman et al. state, to date object definitions for many manufactured products have not yet been developed to make this capacity a reality, however in a few industries such as structural steel and precast, these results have been beneficial. \[xiv\] BIM can provide an accurate idea of the design and material resources required for each portion of a given work. This improves the planning and scheduling of subcontractors and helps to ensure a just-in-time arrival of people, equipment, and materials. This potentially reduces cost and allows for better coordination on the job site.

**Conclusion**

The ultimate implementation of BIM would be an open-source platform where building projects are digitally conceived, programmed, designed, visualized, subjected to various simulations, reviewed for code compliance and constructed directly from the digital model which then would serve the owner in operating the facility. The BIM model (or models) would be a series of interconnected data structures and be directly accessed by all project participants. The realization of this goal would change how projects are created at every stage, yielding new models of design and construction practice. This goal, while theoretically feasible, faces many serious obstacles in reality. No one expects it to be achieved in the near future although advancements are being made every year. The majority of architecture firms are using BIM to develop 2D drawings in a more automated manner, but the linkage to specifications, product information and construction is still lacking. The responsibility for this advancement in is not limited by the technology; rather, as discussed is determined by the cultural and contractual context in which technology is deployed.

Many firms are working to move toward BIM. In a recent survey by the AIA titled The Business of Architecture, more than 34% of firms have acquired BIM software. \[xv\] In another study by McGraw-Hill Construction of architects, engineers, contractors and owners, just under half of all participants reported using BIM or purpose built modelers. In this study 6/10 architects reported using BIM. \[xvi\] In talking with firms in the Salt Lake region, many have adopted BIM but see great challenges in the time and cost associated with adoption into the every portion of the firms daily practice operations. Virtually all see a major gap between digital modeling in BIM for productivity and linking to consultants, owners, and construction scheduling and cost. For these firms, many say they are waiting for the right project that will allow the space to utilize BIM or waiting to be pressured from the owner to do so.

The responsibility is everyone’s in the construction industry including owners, architects, engineers, contractors, subcontracts and all in between. The task for fully integrated project delivery via BIM tools seems to be a daunting task. BIM in the Utah AECO with its accompanying survey, workshop and future planning is intended to facilitate the beginning steps to moving the AEC industry in Utah toward this goal of integration.
iii Eastman: 330-331.
vi ConsensusDOCS consists of twenty-one member organizations, including the Associated General Contractors of America (AGC), the Construction Owners Association of America (COAA), the Construction Users Roundtable (CURT), Lean Construction Institute (LCI), and a large number of subcontractor organizations. See http://www.consensusdocs.org.
viii IDP Guide.
xiii Eastman:180-181.