Integrated Project Delivery Using BIM

By Peter Griem, P.E.

Most engineers recognize that Building Information Models (BIMs) improve visualization, enhance coordination, and promise efficient production of contract drawings. But the true value of BIM isn't realized until design and construction professionals share that model for the benefit of the project.

BIM empowers the collaborative teams envisioned by project delivery methods such as Design-Build, Lean Construction, and the American Institute of Architect's (AIA's) Integrated Project Delivery. The technology will influence design professionals' scope of work – redefining responsibilities and creating new roles for all participants that bring a project from concept to reality.

Integrated Project Delivery

Integrated Project Delivery (IPD) begins with a focus on a set of project-specific design goals, and utilizes technology to achieve those goals. According to AIA, "Integrated Project Delivery leverages early contributions of knowledge and expertise through the utilization of new technologies, allowing all team members to better realize their highest potentials while expanding the value they provide throughout the project lifecycle." *Figure 1* illustrates this concept. Early project decisions have a greater ability to positively impact project costs and functions. The later that a decision is made, the more cost a design change will incur.

An "integrated" team includes all key decision makers and stakeholders in a project. An IPD project benefits when team members identify economies in cost and schedule that are incorporated into construction document details. Good engineers and contractors are invaluable members of an integrated team, because they contribute solutions that enable design goals to be achieved safely, practically, and economically. Both AIA and the Associated General Contractors of America (AGC) have issued standard, contract agreements that create alliances between the Owner, Architect, and Contractor. The agreements encourage collaborative teamwork (in lieu of a "checks and balances" approach that can often turn adversarial) and more equitable sharing of project risk and reward.

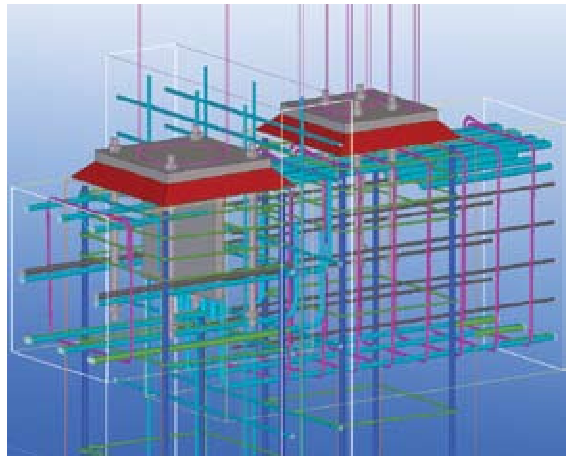

Figure 2: BIM offers a superior ability to visualize and coordinate systems.

In this age of instant gratification, owners not only expect projects to be delivered on-time and on budget, but they expect them to be built faster than has been historically achieved – with little tolerance for errors and omissions. Undoubtedly, BIM has been marketed in a way that establishes expectations that are slightly ahead of their time (or occasionally altogether unreasonable), but clearly the promises of BIM are real. Projects delivered via an integrated approach using BIM will:

- offer a superior ability to visualize and coordinate building systems,
- lead to a reduction of Requests for Information during construction,
- communicate more complete scope, resulting in tighter bids,
- enable shorter lead times and compression of construction schedules, resulting in cost savings and/or added value to an owner,
- and revolutionize the roles of project team members.

Evolving Roles and Opportunities for Structural Engineers

When one engineer's services become indistinguishable from another's, clients will secure those services on price alone, thereby commoditizing the profession. The opportunity to expand the structural engineer's (SE's) role should be embraced. Integrated project delivery systems can increase the profession's visibility among owners and leadership in the construction industry.

A shift to integrated teams will result in more reliance than ever for structural engineers to showcase expertise when selecting structural systems, especially in non-traditional building forms. We will need to articulate the importance of complex structural code requirements, to demonstrate knowledge of alternative structural systems, to consider sustainable design issues, and to foresee constructability issues before they happen in the field.

Structural engineers will be more responsible for leading and proactively coordinating with vendors and consultants to achieve project goals. For example, structural engineers:

- may call on product vendors to provide parametric objects, cost and scheduling data, and product specifications for inclusion in the BIM;

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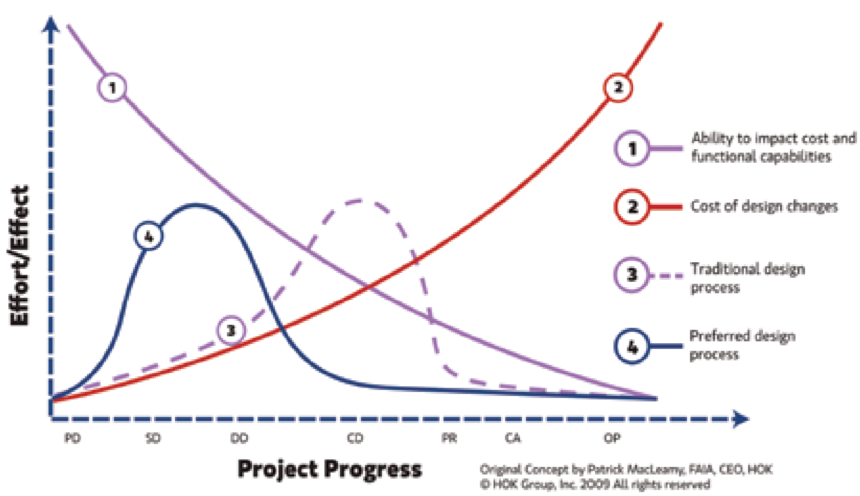

Figure 1: Project Effort and Impact.

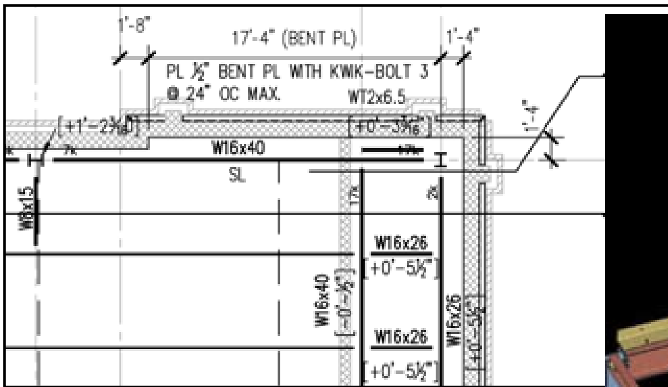

Figure 3: Portion of contract drawing.

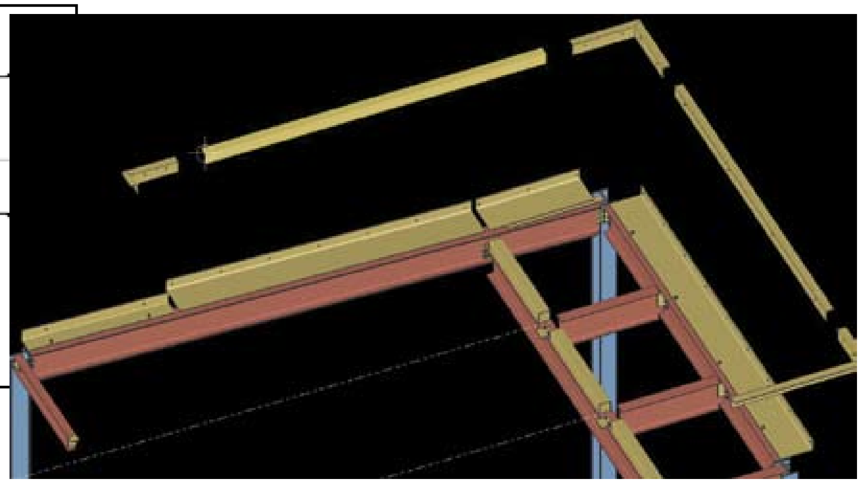

Figure 4: Portion of BIM corresponding to Figure 3.

- may call on structural detailers and specialty structural engineers to help model the detailed information that a contractor needs to fabricate and erect his work;
- and/or may work alongside contractors to consider implications of early-award, design-assist, or Guaranteed Maximum Price projects.

The standard of care will evolve. We will need to provide a level of completeness and accuracy that has historically been delayed until detailed shop drawings. Owners and contractors expect a higher level of quality, precision, and attention to detail from structural engineers because of the importance and complexity of the systems we design. Software advances will enable the inclusion of additional detailed information, and raise the bar.

IPD Examples

The benefits of IPD can be seen at the Capital Preparatory Magnet School, in Hartford, CT. The City of Hartford chose The S/L/A/M Collaborative to design an addition to the school largely because they were confident that an integrated project delivery approach would allow for the addition to open on an aggressive construction schedule. The innovative approach was proposed by the structural engineer in the interview.

The building committee expressed an interest in BIM because they were familiar with reported benefits that 3D modeling resulted in fewer errors and omissions. The structural engineer explained that while this may be true, a real schedule reduction could also be realized if the model was passed from the design team to the construction team.

Construction schedule was identified as the owner's primary concern, and structural steel was identified as the item on the critical path. Because the process was new for everyone involved, a decision was made to issue traditional bid documents along with a BIM model issued "For Information Only." The drawings formed the basis of the contract.

S/L/A/M's structural engineers consulted with prequalified steel fabricators, and hired a local structural steel detailer, T & T Structural, Inc. to be part of the design team and to assist in developing a BIM. Design Data's SDS/2 was chosen as the BIM software platform because of the level of detail that could be produced, and because most local fabricators could use the Computer Numerical Control (CNC) files generated by the software to program their production lines.

S/L/A/M exported the basis for the BIM from RAM Structural System via CIS/2, an electronic data exchange file format for structural steel project information. T & T Structural imported the CIS/2 data into SDS/2, which provided steel sizes, material, general geometry, and beam end reactions. Adjustments to elevations and work points were required, but overall, modeling time for the detailer was greatly reduced.

Preliminary connections, base plates, bent plates, shelf angles, dunnage frames, embedments, and more were modeled by T & T. The detailer identified missing dimensions in S/L/A/M's drawings, and made suggestions to economize details. The comments were incorporated into the bid documents.

The model was provided to all steel bidders, along with preliminary erection plans and details, and anchor bolt and embedment drawings. Fabricators were allowed to revise the model and choose simple shear connections to suit their standard shop practice. The BIM contained substantially more complete information than the hard copy set of drawings, that is, rather than having to interpret where certain details applied on the project, every piece was modeled in its correct location so there was reduced chance for confusion. The model contained every beam, column, bolt, clip and plate required to fabricate the project's superstructure – a level of completion that normally wouldn't be available for several weeks after a contract was awarded.

Figures 3 and *4* illustrate the benefit of providing a detailed model. The model clarifies information such as intent of design and geometric layout. With access to the model, bidders could run an Advance Bill of Materials (ABOM) Report, detailing the size, length, and weight of every piece of steel on the job. Additional data could also be extracted from the BIM, and then imported into FabTrol – i.e. Material Requirements Planning (MRP) software that is commonly used by steel fabricators to help produce estimates and to manage materials, drawings, shop production, and shipping. A complete mill order could be placed upon award, reducing concerns about volatile steel prices.

The fabricator used the supplied BIM. Piece marks were added, and detail sheets were generated and dimensioned for the shop by the fabricator's detailer. The updated model was submitted back to S/L/A/M on a CD, and reviewed electronically via the SDS/2 Global Review Station. The software allowed the reviewer to query database information for any element in the model, and view the relevant piece drawings as CAD files embedded in the BIM.

Review comments, approval status, and a customized electronic review "stamp" were added to sheets or pieces in the model, and plotted as Portable Document Files (PDF's). The PDF's of the reviewed sheets were burned to a CD with the reviewed model. The entire submittal process was paperless.

Shop drawing approvals were received by the steel fabricator before the foundation contractor mobilized on the site.

The integrated approach resulted in lower bids, and reduced lead times for structural steel. Every bid submitted was below the established budget. It is estimated that the BIM saved 6 – 8 weeks off the fabricator's delivery schedule. The savings allowed the owner to pay for enhancements that had a direct impact on students, such as Smart

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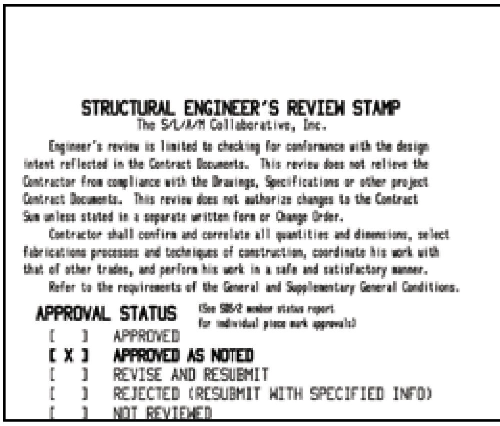
STRUCTURAL ENGINEER'S REVIEW STAMP
The S/L/A/M Collaborative, Inc.

Engineer's review is limited to checking for conformance with the design intent reflected in the Contract Documents. This review does not relieve the Contractor from compliance with the Drawings, Specifications or other project Contract Documents. This review does not authorize changes to the Contract Sum unless stated in a separate written form or Change Order.

Contractor shall confirm and correlate all quantities and dimensions, select fabrications processes and techniques of construction, coordinate his work with that of other trades, and perform his work in a safe and satisfactory manner.

Refer to the requirements of the General and Supplementary General Conditions.

APPROVAL STATUS (See SDS/2 member status report for individual piece mark approvals)

[ ] APPROVED
[X] **APPROVED AS NOTED**
[ ] REVISE AND RESUBMIT
[ ] REJECTED (RESUBMIT WITH SPECIFIED INFO)
[ ] NOT REVIEWED

Figure 5: The BIM was submitted for electronic review. Comments and review stamps were applied similarly to a traditional paper-based review. A portion of a review stamp appears above.

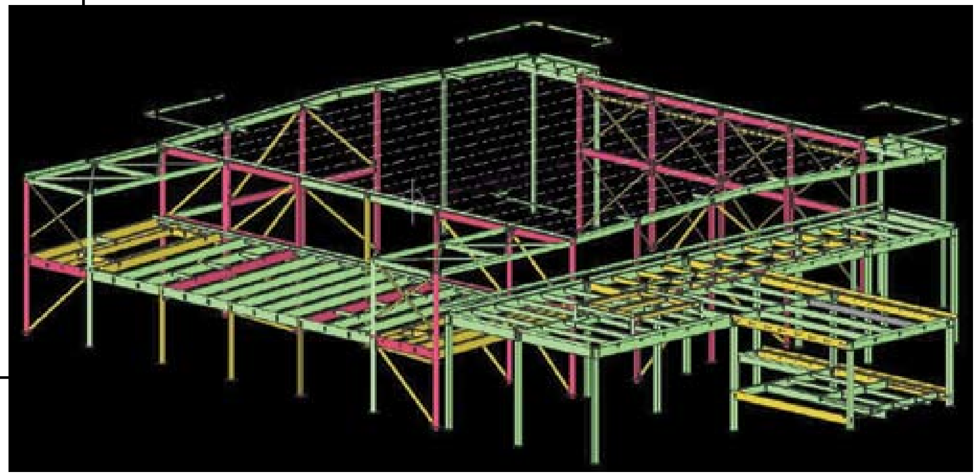

Figure 6: The BIM can be displayed by member approval properties, allowing quick confirmation of project status.

Boards – interactive whiteboards that energize presentations, and engage learners – which were bid as an add alternate.

A similar process was recently implemented for an emergency department expansion at Northern Westchester Hospital in Mount Kisco, New York. The Construction Manager proposed re-phasing the sitework component of the project, but was concerned that, by doing so, there would be a suspension of construction activity while waiting for structural steel. Design engineers were able to demonstrate that ,by supplying a BIM, the steel could be delivered without disruption in schedule, and the owner could realize a savings in General Conditions. S/L/A/M used the opportunity to expand its scope of services to include the design of steel connections. In these examples, the owner recognized the value and benefits of IPD, and acknowledged the increased level of service that IPD systems demand. Additional fees were contracted, commensurate with the increased level of service.

Conclusions

It's important to remember that despite the potential assistance of additional project team members, the quantity of information designed, produced, coordinated, and managed by the structural engineer in an IPD project using BIM is significantly more than that of a traditional project. More time is spent fine tuning instruments of service, such as analytical and production models. (Less progressive engineers might argue that this fine-tuning is micro-managing.)

Tasks are moved forward in project schedules. In these project examples, detailed review of the BIM, akin to shop drawing review, was performed in the design phase.

The ability to convey structural design concepts and details early is essential. Design decisions cannot afford to be revisited late in a project, because as the amount of data in a BIM increases, the effort required to change or manipulate that information increases exponentially.

Flexibility to accommodate different software platforms will be necessary until true interoperability arrives as promised. No individual BIM platform seems to make sense for all projects. BIM platforms have their origins in different areas of practice ranging from design and analysis, to documentation, to fabrication detailing. The most beneficial platform for a project will be dependent on that project's goals.

It is a mistake to limit the use of BIM to automatic drawing generation, clash detection/avoidance, or 3D visualization. Design Professionals must seek ways to utilize and push the technology to advance our profession, and overcome the inefficiencies that exist in the construction industry.

Industry groups such as AIA, AGC, the Construction Users Round Table (CURT), have hailed BIM and IPD systems as "revolutionary," and as a "paradigm shift" in the way structures are designed and built. Parametric modeling, interoperability concepts, and collaborative decision making are all more advanced in structural disciplines than in others. As a result, structural engineers are in a prime position to lead the revolution.▪

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