BIM

Dimensional and Material Quantity Control of Wood-Framed Construction

By Matthew H. Johnson, P.E. and Ariane I. Fund

The industry is saturated with articles and news stories touting the value of building information models (BIM) – 3D parametric models that contain "all" building information. Most articles discuss improved coordination, construction time and cost savings, and the operational benefits of a parametric model. However, some articles are starting to emerge that address several myths of BIM, such as a seamless model transition from design to construction team, and the misuse of models in developing traditional two-dimensional documents from 3D models. There will be much growth and evolution in BIM as fair critiques become more prevalent.

Invariably, and regardless of the article tone, most of the discussion is focused on steel and concrete building typologies. Wood construction is not as often addressed in practice or in publication. In fact, most BIM products, until recently, have focused only on steel and concrete.

Wood-framed construction represents a significant portion of the low-rise construction market and the overall construction market in general. Wood offers great opportunity, via building information models, to the owner and contractor if executed correctly. Use of BIM in wood construction can reduce the required material on-site and assist the engineer in providing additional and clearer details for typical and atypical wood-framed construction.

BIM and Wood Design

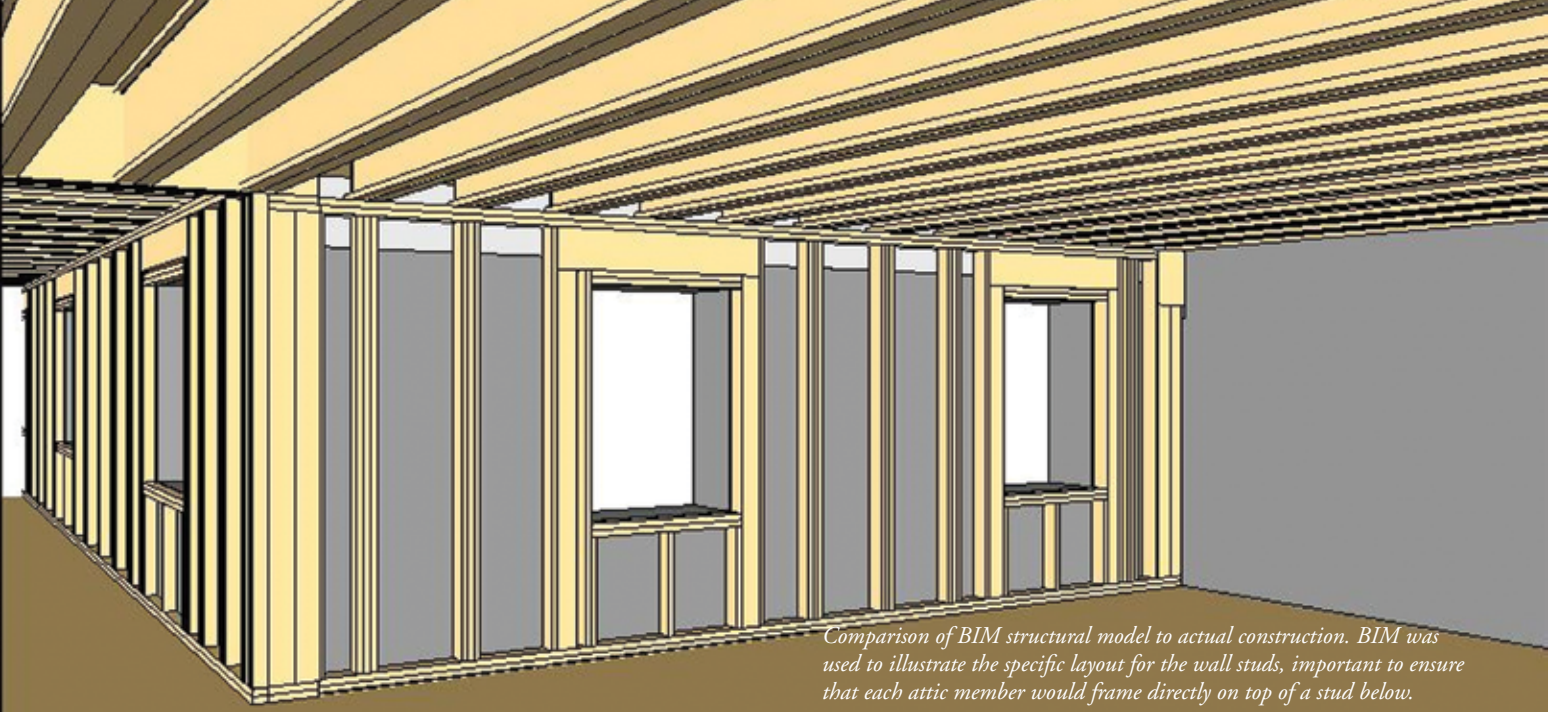
Traditionally, the structural engineer has developed representative wood-framing plans for the contractor. Where structural steel-framed drawings often exhibit nearly exacting dimensional control for each piece and every connection, wood-framed construction documents provide floor and wall types with plan location only. In most cases, final detailing and dimensional control of most individual pieces is left to the contractor on-site. The contractor refers to notes, details, or elevations provided by the engineer for material specifications and typical stud spacing, blocking, nailing, etc., to piece together (literally and figuratively) the final construction.

Via use of 3D parametric models and a change in the production of traditional 2D construction documents, the engineer can provide significantly greater drawing details, potentially reduce material required for construction, and minimize conflicts between disciplines. Use of BIM allows the engineer to take more control of building details. By using BIM, each and every floor joist and wall stud can be modeled, in its intended location, with a higher level of dimensional control. In this way, the engineer can specifically design for each unique framing case that arises, leading to potential material savings.

BIM offers an additional advantage for wood-framed buildings since, generally, they do not undergo the traditional shop drawing process of most steel or concrete buildings. BIM thus allows engineers and contractors one of the few opportunities to visualize how each member will fit together before they are on-site being constructed. This will allow for any atypical framing conditions, which can result in requests for information (RFI) during construction, to be worked out in advance of actual construction. Even a typical detail, such as a header, can be designed more efficiently since the exact number and location of floor joists the header is required to carry will be set. Furthermore, exact material takeoffs can be made directly from the model. As an example, instead of an engineer simply indicating stud wall blocking at 4 feet on center, he/she can detail in elevation the exact quantity and length required, including precise spacing within the height of the wall. The ability of the engineer to detail nearly exact material quantities will limit any excess or incorrect materials on site, potentially saving the owner money.

The other big advantage is in the coordination between disciplines, particularly between mechanical, electrical, and structural. As any structural engineer of a wood building is aware, the nature of the material allows it to be cut and penetrated on-site for the passage of pipes, ducts, conduit, and equipment placement. In a traditional building schedule, when this occurs, the structural engineers' work is generally complete, and they are often not consulted or even aware of the implications this may have. By specifying exact locations for studs and joists in a parametric BIM model, the mechanical, electrical, and plumbing engineers are better able to coordinate and reduce the locations where their equipment will impact structural integrity. The locations where interference is unavoidable and a structural member must be cut can be determined ahead of actual construction, allowing the structural engineer time to thoroughly review the impact and to make necessary accommodations. However, as with all BIM projects, this advantage can only be realized if all disciplines are on-board from the beginning and working in coordinated models.

To achieve potential savings in material and reduction in on-site conflict, this style of more detailed modeling and documentation requires



Comparison of BIM structural model to actual construction. BIM was used to illustrate the specific layout for the wall studs, important to ensure that each attic member would frame directly on top of a stud below.

a shift in construction practice for wood-framed buildings that will not be without hurdles. Most significant is the reliance on contractors and builders to adopt new methods during construction, a challenge in a field that is based on years of tradition and fine-tuned building methods. Contractors will have to consider wood-framed buildings in a similar manner to steel buildings, with members having specific locations. As opposed to a few typical details that apply everywhere, they will face more details, ideally optimized for each unique condition throughout the building. This also places additional burden on the engineer to both develop these details and observe that they are being constructed as indicated. Until recently, modeling every member of a building could be a tedious task, especially if the parametric capabilities for wood stud walls and floors are not built into the software. BIM software developers are now beginning to realize the importance of having this ability, and many improvements have been made to aid in modeling.

Case Study

BIM was utilized in a recent wood-framed reconstruction project. An existing 1955 timber and masonry building was destroyed by fire. The historic, exterior masonry walls remained, and the decision was made to construct a nearly new wood-framed building within the existing enclosure. Updating to modern HVAC resulted in heavy roof loads due to attic-level HVAC equipment.

To ensure that loads were carried in a direct path down to the foundations, each stud was modeled at the first and second floor directly on top of each other, and aligned directly below each attic and roof member, reducing the need for headers at the roof and second floor. Positioning each wall stud had the additional advantage of allowing efficient frame-out of window and door openings. In certain cases where wall studs would be close to windows following the typical spacing, headers were extended to be longer than the window width to sit on these studs, as opposed to adding additional studs close to windows. It was also useful to model the exact extents of the plywood decking and wall sheathing. In addition, many atypical conditions were more easily discovered using BIM.

One such instance was the eave condition. Through 3D modeling, it was determined that in some locations the attic floor framing was at an elevation that interfered with the roof rafters, potentially requiring significant notches to be cut. Use of the model to visualize their exact location clearly demonstrated the conflict to the architect, and an appropriate detail was developed to accommodate a new attic floor while maintaining the historic, existing eave height and soffit detailing.

While the BIM model did lay out every framing member, some of the challenges mentioned still surfaced. The contractors did not consult the drawings for exact dimensioning of studs. They instead relied on traditional methods by arbitrarily choosing a starting point for the framing and proceeding along-wall with the typical stud spacing. This resulted in studs that were not aligned vertically between the first and second floors, and ultimately required them to move stud framing or add additional studs to provide a direct load path.

Another disadvantage is that many detailing components, such as hangers and bolts, are not yet efficient to model as 3D objects in most commercially available BIM software or third-party products. Modeling objects in 2D eliminates the parametric capabilities of a BIM model, and is an area where the software needs improvement to be employed in the most efficient manner.

Using lessons learned on this project will help in developing an efficient BIM model for subsequent wood-framed projects. Additionally, details and notes will more clearly indicate that there is a specific dimensional control employed in the drawings. A pre-bid or preconstruction meeting will also be utilized to review the drawing details and dimensional framing concepts.

Conclusion

Wood-framed buildings are another opportunity for engineers to use BIM to improve upon both design documentation and coordination between the design and construction teams. In wood-framed construction, BIM offers the additional opportunity to aid in achieving material efficiency. While the dimensional control for wood-framed buildings provided by BIM can help realize these goals, it will require clear notation from the designer to the contractor until dimensional control of wood-framed buildings becomes standard practice. Additionally, the developers of BIM software, third-party software providers, and wood-product manufactures will need to speed up the development of wood-based modeling tools before the full potential offered by BIM can be attained.▪

Matthew Johnson, P.E. is an Associate Principal with Simpson Gumpertz & Heger Inc. in Waltham, MA. He can be reached at ***MHJohnson@sgh.com****.*

Ariane Fund is Staff II – Structures with Simpson Gumpertz & Heger, Inc. in Waltham, MA. She can be reached at ***AIFund@sgh.com****.*