BIM FOR MASONRY: A CASE STUDY OF BIM INTEGRATION IN A NEW LABORATORY BUILDING

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ABSTRACT

A major healthcare institution in the Chicago area recently constructed a large laboratory on its hospital campus. The 45,000 sq. ft. (4,180 m2) basement of this facility was divided into many small rooms and spaces constructed entirely of 17'-6" (5.3 m) high masonry partitions, corridor walls and shaft walls (Figure 1), all of which were grouted and reinforced vertically and horizontally. The laboratory function of the building necessitated extensive and well- coordinated mechanical, electrical, plumbing, and fire protection systems, all running within and through the reinforced masonry walls. The entire project, including the masonry, was constructed with full BIM integration. This paper will document the construction process of these masonry walls built to accommodate over 1,500 penetrations, pipe sleeves, and embedded vertical systems per the BIM model. It will examine the role of tablet computers and other non-traditional information delivery methods, as well as communication and coordination between the masonry and related trades in the construction of these complex masonry walls.

Figure 1.
Bricklayers constructed the masonry on this new laboratory building using BIM technology and tablet computers.

BACKGROUND

Project Information

The project name, owner, and architect are withheld. The general contractor (contractor) was Power Construction, Chicago, Illinois (Chris Coyne, Superintendent; Matt Lepper, Project Engineer; Jim Schrader, BIM Manager). The mason contractor was Richards and Weyer Construction Co., Inc (Peter Sindic, Project Manager; Larry McGaffee, Foreman). The mechanical contractor was Mechanical Inc.; the electrical contractor was Meade; the plumbing contractor was Hill; the fire protection contractor was U.S. Fire Protection. The Mechanical/Electrical/Plumbing (MEP) trades are credited here because they worked collaboratively with the mason contractor during construction. The contractor's BIM Execution Plan (BEP) required each specialty contractor, including the mason contractor, to comply with BIM coordination procedures set forth by the contractor.

Sequencing of Trades

Due to the building's unique laboratory function, its design required a complex network of ductwork and piping for the following utility services, which for simplicity's sake this paper will refer to as MEP:

- Electrical
- Fire protection
- HVAC
- Water
- Mechanical pipe
- Medical / Lab pipe
- Domestic Water Vent

The contractor made the early decision to sequence the installation of the MEP piping and ductwork within and through the masonry walls simultaneously with the masonry construction (see Figure 2). Only a few large sections of ductwork direct-mounted to the structural slab above were installed prior to the masonry. The contractor rationalized that the thousands of pipes and ducts at various elevations would present an unnecessary obstacle to the masons if they were installed prior to the masonry. Conversely, installing the MEP components after the masonry would require excessive cutting through block walls, resulting in inefficiencies. Therefore it made sense to build the block walls with the accommodations for pipes and ducts in a single operation, with the MEP trades working side by side with the bricklayers. This unconventional work method called for a comprehensive and accurate BIM model to facilitate construction.

Figure 2.
The bricklayers worked alongside the MEP trades to install pipe sleeves through the masonry walls as they were constructed, per the BIM model.

THE BIM MODELS

Architectural Model

As part of the construction documents process, the architect issued a preliminary BIM model done in Revit software. This model was very basic, showing only the masonry wall locations and dimensions, without much detail on the interface of MEP elements intersecting or inside the masonry walls. The model was useful to the contractor for bidding purposes, but they needed a more detailed model for construction.

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Coordination Model

Upon award, the contractor imported the architect's Revit model into Navisworks and began to add information necessary for construction. The contractor's model would supersede the architect's model and would become the only model used for construction and as-built documentation of all portions of the project, including the masonry. The contractor's Navisworks model was known as the coordination model (Figure 3) because it showed the work of all trades and the interrelationships between them. The coordination model's purpose was not to show a great level of detail, but rather to provide a comprehensive overview of the work of all trades.

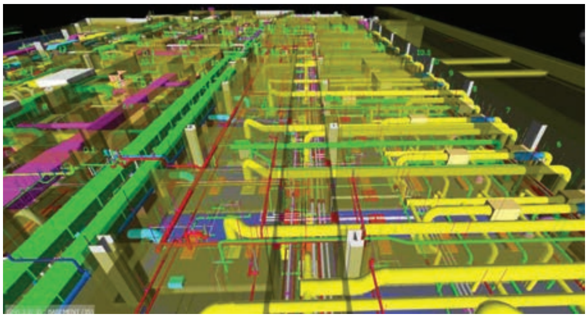

Figure 3. *The coordination model shows MEP pipes and ducts passing through the masonry walls. See* **Figure 4** *caption for the color coding legend.*

To generate the coordination model, the contractor gathered and processed information from the MEP specialty contractors. Some of the MEP contractors had done their own BIM models in a variety of software platforms, and some had only 2D drawings. The mason contractor had neither. Among the BIM models and drawings of the MEP trades, there was no consistency in dimensioning techniques, i.e. some would dimension to the bottom of their duct or pipe, and some would dimension to the center. Therefore, it became the contractor's challenge to gather the information and standardize it in the coordination model.

The coordination model was generally used only for reference. Members of the project team viewed the coordination model on computers and tablets, but it was rarely printed. Throughout construction, the contractor maintained the coordination model, keeping it current as RFIs and changes to construction were processed, for example, changing the locations of doors in some of the masonry walls.

Composite Model

While it was the function of the coordination model to provide a comprehensive overview of all the trades' work, the contractor generated a separate BIM model, the *composite model*, to provide information for all MEP elements passing through and within the masonry walls. This model was to be detailed enough for construction purposes. In fact, the composite model was generated for the benefit of the mason contractor and the related MEP trades working alongside the bricklayers.

The composite model was used to generate dimensioned, 2D plans and elevations (Figures 4 and 5) in PDF format that were uploaded to a cloud storage server and accessible to the bricklayers in the field via tablet computer and/or printed drawings.

These plans and elevations showed precise locations and sizes of over 1,500 penetrations required of the masons and related trades during construction of the masonry.

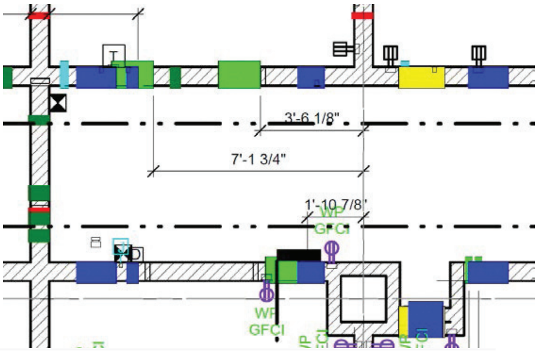

Figure 4. *This plan view of the composite model shows some of the MEP penetrations. Light green is mechanical, dark green is water, yellow is electrical, red is fire protection, blue is HVAC, and cyan is plumbing / domestic water vent.*

The penetrations through the masonry, whether round or rectangular, generally had a sleeve of sheet metal or plastic that the bricklayers carefully placed in the block wall at the precise location and elevation called out on the composite model drawings (Figures 6 and 7). The length of the sleeve corresponded to the thickness of the wall, and its dimensions corresponded to the pipe or duct to be run through the sleeve. In some cases, if two or more sleeves were in close proximity, they would be boxed out by a larger rectangular sleeve. The composite model dimensioned round sleeves to their centers, and rectangular sleeves to their bottoms. Dimensions appeared on the model to the nearest 1/16 in. (0.15 cm), but the tolerance was about ±1/4 in (0.6 cm).

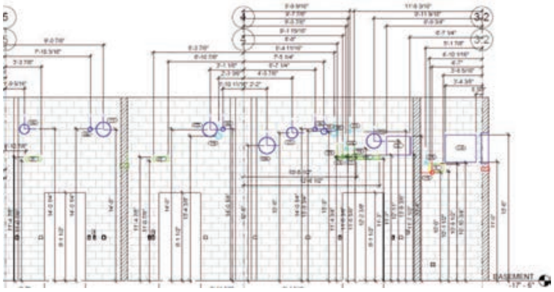

Figure 5. *This partial elevation view of the composite model locates the MEP sleeve penetrations for the bricklayers. Each sleeve has a unique number and each is color-coded per trade. See* **Figure 4** *caption for the color coding legend.*

Figure 6. *A bricklayer installs mechanical duct sleeves at precise locations per the BIM model, as he constructs the masonry.*

The contractor built the composite sleeve model in Revit. It was generated after the coordination model, and was used to support, validate, and verify the coordination model. Any changes in construction were first made on the coordination model, and then, if necessary, made on the composite model. The composite model was particularly useful to the mason contractor, as it consolidated information from other trades and effectively replaced seven individual sets of MEP shop drawings that would otherwise be necessary. During construction, any updates to the sleeve model were electronically pushed to the mason contractor's tablet computer.

Control of the BIM Models

As in typical construction projects, if any changes were necessary during construction, for example if a wall or door were to change location, the architect would issue the contractor a bulletin and possibly an accompanying sketch to graphically describe the change. From the time construction began, however, the architect was not able to make changes to the coordi-

Figure 7. *As the concrete masonry was constructed, the bricklayersinstalled 468 sleeves for HVAC, 69 sleeves for electrical, 159 sleeves for mechanical pipe, 257 sleeves for fire protection, 231 sleeves for plumbing, 343 sleeves for water, and 10 sleeves for miscellaneous, resulting in a total of 1,537 sleeves in the masonry walls.*

nation model, the primary BIM model. The coordination model was under the control of the contractor throughout construction. The architect and other parties could view the model, but the contractor was the only one able to make changes to the model during construction. Upon completion of the project, the BIM model would be turned over to the owner for facility management.

WORKFLOW

Construction Workflow

Unlike most projects where the masonry crews work relatively independently of other trades, this project relied on close communications between the contractor, the mason contractor, the mechanical contractor, the electrical contractor, the plumbing contractor, and the fire protection contractor. These various trades shared not only information; they also shared workspace, as the respective MEP trades would install their components in the masonry walls from the masons' scaffolding when the bricklayers were ready for them (see Figure 8).

Figure 8. *A bricklayer (left) works in alongside a pipefitter (right) to simultaneously construct the block wall and the plumbing contained within it.*

The masonry foreman laid out the block walls with chalk lines on the concrete floors, indicating the various MEP components with different colors of chalk. The information was verified by the contractor and the respective MEP foremen.

Each Tuesday morning, the masonry foreman marked up a copy of the basement floor plan to indicate where the bricklayers would be working that week, and communicated that with the contractor. The contractor then advised the MEP contractors of the areas of work so they could prepare their labor and materials. The MEP trades needed to know the masons' plans 4 to 5 days in advance in order to relocate their manpower from other areas on the job, and to stage their horizontal penetration sleeves and vertical in-wall piping, making sure to have them ready for the masons at the proper time. Each day, sometimes twice per day, the mechanical and plumbing foremen checked in with the masonry foreman on specific manpower and material needs.

Prefabrication

The central role of the BIM models and the open lines of communication among trades opened the door to prefabricate plumbing and gas assemblies, freeing up valuable work space and speeding up the construction schedule of the masonry walls in the basement. The basement level contained 50 lab sinks, 15 toilets, and 50 prefabricated gas assemblies with plumbing running either inside the block walls or in a chase between block walls. For the plumbers and pipefitters to assemble the piping on-site per conventional methods, would mean increased demand for work space in areas that were already congested. Therefore, the plumbing and gas lines were built in the plumbing contractor's shop on racks made of steel struts and transported to the site prefabricated. Once the racks were in place but before the masonry began, the contractor scheduled plumbing inspections by the municipality, which required two days' notice. Upon successful inspection, the bricklayers built their masonry around the racks of plumbing and gas lines.

Figure 9. *The BIM model made it possible to prefabricate the toilet room plumbing assemblies on steel strut racks to conserve space on the jobsite. The plumbing racks were integrated into the block walls per the coordination model.*

Documenting Changes During Construction

Early in the development of the BIM model it became apparent that the mechanical contractor required more room for mechanical equipment along the north wall of a basement mechanical room, which necessitated the relocation of a door in one of the masonry walls. The contractor issued an RFI and change request to the architect, which was approved. The contractor subsequently made the change to the coordination model and generated a dimensioned 2D plan view of the change. The revised plan and its corresponding change documentation were then pushed to the bricklayers in the field, where the masonry foreman accessed the new information on his iPad. The RFI and the change order became linked to the drawings on the cloud storage server.

CONCLUSIONS

This project required tremendous efficiencies of the bricklayers due to the interdependencies between the masonry and the thousands of MEP components within the walls. For the duration of the basement construction, the bricklayers were arguably the most critical trade on the project, dictating the schedules of the MEP trades. According to Pete Sindic, project manager of Richards & Weyer Masonry,

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“There was a high level of cooperation and teamwork between the bricklayers and the other trades throughout the project.” Chris Coyne, Superintendent with Power Construction, said “This was one of the more intense masonry projects I’ve worked on with the prefab in the masonry walls coupled with all the overhead sleeves and the amount of reinforcing. It required a high degree of organization by the masonry contractor as well as working hand in hand with the MEP trades in a team environment. Every day was a new adventure in the basement. Now that the masonry is finished (Figure 10), we all get lost down there due to the amount of masonry walls and the maze-like configuration.”

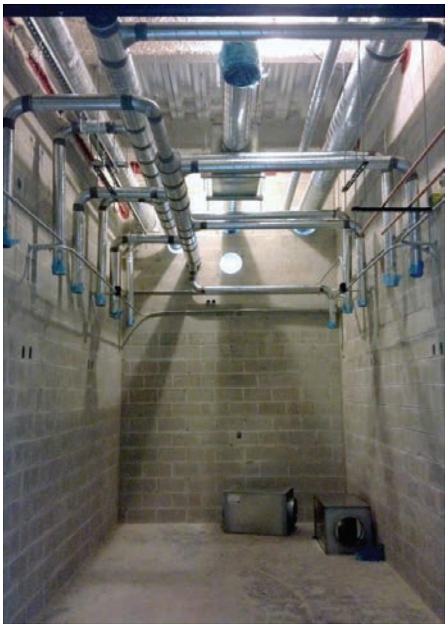

Figure 10. *Upon completion of the masonry work, the MEP trades were able to easily install their pipes and ducts without cutting through the masonry due to the well-coordinated sleeve penetrations.*

This laboratory is a good example of project-wide reliance on the masons, a dependency that will become prevalent as more projects are delivered using BIM. With the advent of the BIM for Masonry (BIM-M) initiative, an industry-wide task force comprising architects, engineers, contractors, masonry suppliers, labor unions, and academia to promote and develop tools that will facilitate the use of BIM-M, this author predicts that future projects will see an even greater integration of BIM-M as a design and construction tool, realizing further economies in designing and building with masonry.

References

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