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Chad A. Van Kampen, Barry N. McKinley, and Dan J. Ritzert

Building information modeling project coordination: The all-in approach

- This paper presents an example design-build project using building information modeling for a processing facility.
- The project team developed a model early in the project to support coordination between all team members to deliver a successful precast concrete structure to the owner.

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Accustomed to providing true vertically integrated solutions as a single-source, self-performing design-builder of complex food, beverage, and pharmaceutical processing facilities, the firm Shambaugh & Son LP was selected to design and construct MWC LLC in St. Johns, Mich., a cheese and whey processing facility that processes 25% of the milk produced in the entire state into cheese and whey protein powders. This article describes how the entire design-build team successfully worked together and provides lessons learned for use on other similar projects. The project team's total commitment to using building information modeling (BIM) as its core planning and design tool for this facility enabled complete and efficient coordination of thousands of unique precast concrete building elements with the complex mechanical, electrical, and plumbing (MEP) and process systems in the facility. The benefits of this approach extended from the early planning stages through construction to the as-built documentation of the completed project.

The team with the right tools

MWC, the facility owner, is a joint venture between Glanbia Nutritionals and two dairy cooperatives: Dairy Farmers of America Inc. and Select Milk Producers Inc. Early in the project, MWC, with support from Shambaugh, chose to advance design of a total precast concrete structure for the approximately 220,000 ft^2 (20,438 m^2) of receiving and production spaces. The use of precast concrete with a food-grade interior finish coupled with field-applied high-performance coatings provides

The MWC LLC processing facility dryer structure is constructed of precast concrete. Courtesy of Shambaugh & Son LP.

a finished surface that is durable, free of voids, smooth, resistant to chemicals, and easy to wash down.

For this project, the precast concrete team had to be capable of creating a model with a level of development of 500 for the precast concrete structure. This model needed to include all elements, such as embeds, reinforcing, and connections, and it had to be maintained as the construction progressed on-site. Shambaugh selected Kerkstra Precast as the manufacturer, and Kerkstra, in turn, selected PTAC Consulting Engineers as the specialty engineer. PTAC is an Autodesk Architecture, Engineering, and Construction (AEC) Industry Partner (a third-party technology providers that engage with Autodesk to deliver discipline-specific regional solutions that complement Autodesk software offerings) and has developed the software solution EDGE^R for modeling precast concrete structures from conceptual design to production detailing. EDGE^R was used extensively on this project. Because it is developed to work with the Autodesk Revit software, EDGE^R is compatible with all clash detection and coordination methods widely used by the AEC industry.

Initial design challenges

A distinctive aspect of processing facility construction is that the owner and design-build contractor must first define the process before ultimately conceptualizing and designing a building envelope to enclose the process.

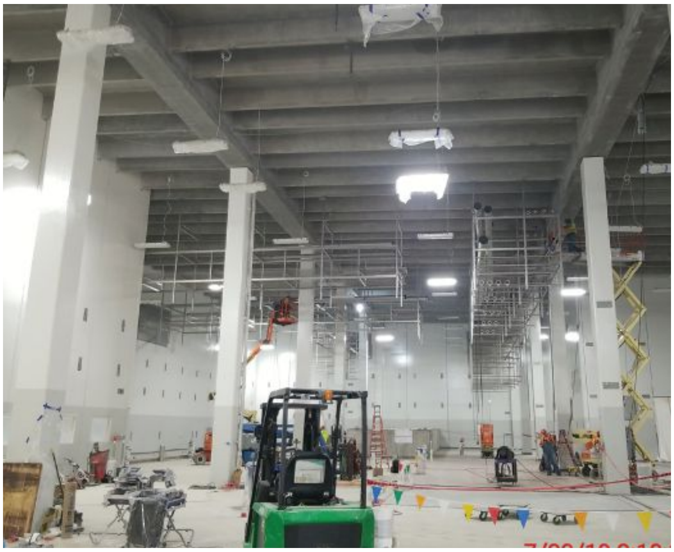
- What is being produced?
- What equipment is being used in the process?
- What access to equipment is needed for people, materials, trash removal, maintenance, and so forth?
- What utilities are required for the process?

Processing facilities are filled with complex equipment and tanks, they can be wet or dry environments, and they have tremendous utility loads that usually require a robust utility infrastructure throughout the facility. Such facilities can have significant equipment and piping loads suspended from the structure or passing through walls of the plant, and they have areas that must be easily cleanable. It is cost prohibitive to construct an entire building for the worst case scenario; therefore, every processing facility is a unique design and designs for areas within the facility are specific to the process needs. For these many reasons, Shambaugh used BIM to coordinate every detail of the MWC project: foundations, floors, walls, structure, equipment, piping, conduit, lights, sprinklers, and so forth. The firm is especially capable of leading process facility construction projects because of its in-house process, mechanical, electrical, automation, and sprinkler design resources, as well as its self-perform delivery strategy.

One challenge on this project was the coordination of the more than 3150 stainless steel embed plates and many pass-through openings to accommodate the miles of pipes, cable trays, conveyors, and equipment supported from and routed through the 2107 pieces of precast concrete. Embed plates in the bottom of double-tee stems were recessed to provide optimum surface area for pipe support attachment; however, prefabricated 50 ft (15 m) long pipe racks still needed to be constructed to very tight tolerances (±¾ in. [19 mm] over the length of the building) to avoid field rework, and that could most efficiently be accomplished through the use of BIM using Navisworks to coordinate the multiple trades on the project.

Another challenge was the design of the precast concrete dryer building, which encloses and supports a spray dryer with

A 50 ft long pipe rack is staged for lifting in the morning. Note: 1 ft = 0.305 m. Courtesy of Shambaugh & Son LP.



A 50 ft pipe rack is suspended from the structure and welded to embeds on the same day. Courtesy of Shambaugh & Son LP.

an operating weight of about 100,000 lb (444.8 kN) from one of two elevated decks. The precast concrete building needed to be partially erected and left open to facilitate installation of the large dryer equipment before ultimately being dried in. Roof panels were left removable during construction to facilitate the installation of large ducting and the removal of boom lifts as building finishes were completed.

The modeling team settles in

As the project developed, team members continued to identify challenges, including heavy loads in the utilidor area, multiple process vendor models, 905 embedded electrical assemblies, 3153 stainless steel vendor-specific plates, leave-out areas needed for equipment, penetrations through precast concrete required for various trades, and clear-height requirements. Intensive weekly virtual meetings were held at Shambaugh's office, with multiple models being actively coordinated at the same time, including the precast concrete model. Each meeting lasted several hours and addressed, for example, coordination of embeds, design loads from piping, electrical boxes, and precast concrete joint panelization.

In these meetings, PTAC as the precast concrete specialty engineer actively moved and adjusted precast concrete elements, reviewing the modeling of penetrations, embeds, and blockouts in real time to confirm that they would be acceptable. This process eliminated hours of back-and-forth communication by allowing all stakeholders the ability to make design option decisions in real time with the entire team. Because team members could visualize all advantages and disadvantages of each design option within the model, they had the best information for decision-making. Kerkstra assessed the precast concrete elements in real time for manufacturing and handling constraints, and the project's architect of record also participated in these meetings; thus, all major parties on the project collaborated to actively build a complete model prior to the start of fabrication.

The participation by all vested team members ensured that each phase of the project was fully coordinated before fabrication ticketing commenced. This essentially eliminated any reticketing due to MEP adjustments, vendor changes, or structural adjustments to loading. Another benefit to this approach was that the participation of the full team ensured rapid approval of submittals and calculations.

Coordination is key

It was critical to the success of the project that the precast concrete conceptual design and schedule (for example, detailing, prefabrication, delivery, and erection) be identified before completing the final schedule for the project. Crane access to areas and temporary deadman bracing would make it difficult for other trades to work in areas at the same time that precast concrete was being installed. Priority areas were identified so that spaces requiring the most field labor for MEP trades could be moved to the front of the schedule. These plans required that the building be constructed in an unconventional manner by moving the crane around the site and sometimes bringing a second crane on-site for erection.

Subcontractors and vendors relied on the early schedule developed by the Shambaugh, Kerkstra, and PTAC team for mobilization and sequencing of their deliveries and resources. Shambaugh's project management staff kept the entire team focused on priority areas during early design review meetings and adjusted models for other areas as needed to keep the most critical areas of the project moving. As new and updated process vendor penetrations and load data became available, it was coordinated within the model. In some cases, changes were made after tickets were released; however, with the fabrication ticket modeled, those changes would be quickly incorporated and updated tickets issued prior to fabrication.

Using BIM ensured that the latest design information could always be available and reviewed in real time to eliminate clashes between trades and ultimately any rework. BIM also provided a detailed road map for all trades to understand how the building's precast concrete components were to be erected.

Advantages of BIM for design-build projects

One of the biggest benefits of the design-build delivery method is the time saved because early construction activities can commence while detailed design for later activities continues. On this project, the model generated during the early design activity was not only beneficial for coordinating the design of the building but also assisted in the actual construction. During construction, the project team used the in-progress model to coordinate various work, such as deep foundations, other building trade activities, major piping and tray racks, and process equipment installation. BIM was used on this project not just to generate precast concrete tickets but also to guide construction from the earliest foundations and underground process waste piping to the last piping and wiring of equipment. Shambaugh had a team of more than 20 designers using Autodesk Plant 3D to incorporate piping into their model. They then used the model and Trimble Total Stations to lay out and install piping in the field. The construction team referenced the model when coordinating deadman bracing to ensure that buried process waste piping was not damaged by deadman or helical anchors. Because the underground process waste piping was installed with the Trimble Total Station system using control points generated by the model, the model provided precise as-built information about the underground piping for coordination.

The total BIM concept adopted by the project team was crucial to coordinating the thousands of vendor-required embeds and openings in the precast concrete elements. All parties were dedicated to producing a fully integrated and coordinated project model. For example, MEP trade partners provided content to be directly integrated into the precast concrete construction model, thereby ensuring that it was accurate and complete with all necessary material detailed and quantified. Because PTAC's own EDGE^R was used to create and coordinate the precast concrete model from project inception, PTAC was able to move directly to piece details for production while ensuring all materials and hardware for the more than 2100 members produced were modeled to a fabrication level. This approach optimized the full production detailing process and ensured that all piece details were produced to the design accepted by all parties during BIM coordination. The traditional method of coordinating MEP embeds and openings would have involved manual markups of the precast concrete drawings and multiple rounds of reviews by all parties, which would have added weeks, if not months, to the efforts of coordination and resulted in a less accurate final product.

PTAC was also contracted to perform the erection bracing plan for the structure. Using the EDGE^R software, the bracing plan was modeled three dimensionally, which allowed for coordination of bracing issues that would typically be difficult to foresee with simple two-dimensional plans. Helical brace interference with underground utilities, foundations, and vendor process waste piping was eliminated, ensuring that full coordination of brace anchors, sizes, and quantities required for each erection phase was possible.

Utilizing technology embraced by the entire design team, Shambaugh created a federated model from all design trades and performed real-time clash detection that was effectively carried through to piece detailing, production, and erection of precast concrete; installation of pipe racks and equipment; and ultimately the tie-in among all the various equipment, utility, and building components. The use of this technology

An Autodesk Navisworks in-progress model shows building and piping in the receiving area. Courtesy of Shambaugh & Son LP.

The final in-place construction is shown for the building and piping in the receiving area. Courtesy of Shambaugh & Son LP.

prevented human error during the analysis of interferences across all trades.

Proven results

Because the process start-up schedules could not be delayed or adversely impacted, the elimination of downstream delays was a pivotal part of the project's success. The production of precast concrete for this project required continuous fabrication of over 2100 pieces with more than 4000 critical vendor-specific elements, including 900 electrical boxes with conduit and 16,865 ft^2 (1567 m^2) of vapor barrier. The use of BIM and up-front coordination of these items involved several thousand hours of labor that ultimately eliminated production and installation delays. BIM coordination helped the job installation proceed without any delays and built camaraderie among the team members, which they drew upon when needed to quickly rectify anomalies with noninvasive solutions. Engineering time spent managing and rectifying missed MEP penetrations or jobsite conflicts was reduced by 60% compared with similar projects that did not use BIM coordination.

In the new facility, finishes inside the process spaces are cleaner than is typical for this type of processing operation because embed plates were recessed and fixed to precast concrete at the fabrication plant rather than in the field with fasteners. This approach also minimized the need for floor post supports, which create harborage points at the dirtiest part of the space and make cleaning more difficult. Process piping, utility piping, and cable trays were coordinated onto combined racks supported from the structure, minimizing anchorage points, conserving space, and optimizing prefabrication opportunities. Pipe and conduit penetration windows constructed with stainless steel insulated metal panel infills provided trades an easy path into production spaces. These same windows were planned to allow for expansion, offering future projects a road map through the precast concrete walls that will eliminate the need to evaluate new penetrations through the precast concrete. Because of this, the customer was provided a much higher-quality facility than if BIM coordination had not been adopted as effectively.

Conclusion

From production ticketing to installation, the ability of PTAC to navigate the precast concrete model to generate the erection drawings and fabrication tickets was the critical link between Shambaugh and Kerkstra.

The dedication of all participating trades to the creation and maintenance of a model of this quality also contributed to the project's success. Benefits for Kerkstra of the coordinated, BIM-driven approach included a faster submittal schedule, faster ticketing, reduced coordination issues in fabrication, cleaner orders on long-lead items such as stainless steel, and almost no erection repairs.

This project demonstrated the vital importance of Shambaugh's top-down commitment to the design-build process, adequate resources with BIM experience, and buy-in from key subcontractors. Collectively, these elements helped the team coordinate and maintain a model that reliably served all parties during design and construction. The advantage to schedule on this 27-month project was easily 3 to 6 months, and it would have been challenging to provide the same high-quality, state-of-the-art, cleanable installation without BIM.

About the authors

Chad Van Kampen, MASCE, PE, LEED AP BD+C, LPCI, is a licensed professional engineer in multiple states and a preconstruction engineer and project manager with Kerkstra Precast in Grandville, Mich. He has a BS in civil engineering from Calvin College in Grand Rapids, Mich., and extensive senior-level management experience with large complex projects centered on the precast concrete construction industry. Van Kampen has worked on precast and prestressed concrete structural and architectural projects with a focus on conversion from other materials and is a leader in promoting alternative reinforcement. An active member of PCI and Altus-Group, Van Kampen serves as chair of the PCI FRP Composites Committee and Total Precast Systems Committee and vice chair of the PCI Hollow Core Committee.

Barry N. McKinley, PE, is president of PTAC Consulting Engineers in Monroeville, Ala. He has 35 years of experience designing precast, prestressed concrete structures in the United States and internationally. He is active with PCI and currently serves on the Industry Handbook Committee and the Technical Activities Council.

Dan J. Ritzert, DBIA, is senior vice president and is responsible for the Shambaugh & Son division that provides fully integrated, single-source design, installation, and maintenance of highly automated, hygienic processing facilities for the dairy, pharmaceutical, beverage, meat, and snack food industries. Ritzert has been a valued member of the Shambaugh team for more than 20 years. His experience, from field piping installer to leader of the firm's engineering groups, makes him especially qualified to lead teams during conceptual design, scheduling, and budgeting phases on often highly automated, process-intense, schedule-critical projects. Ritzert earned his BS in construction engineering management from Purdue University in West Lafayette, Ind. His professional background includes multiple certifications and training accolades, including Indiana Fundamentals of Engineering licensure, DBIA certification in design-build project delivery, and journeyman plumber licensure in Indiana.

Abstract

The design-build team of Shambaugh & Son LP, Kerkstra Precast, and PTAC Consulting Engineers worked together to design and construct MWC LLC in St. Johns, Mich., a cheese and whey processing facility that processes 25% of the milk produced in the entire state into cheese and whey protein powders. The project team's total commitment to using building information modeling as its core planning and design tool for this project enabled complete and efficient coordination of thousands of unique precast concrete building elements with the complex mechanical, electrical, plumbing, and process systems in the facility. The benefits of this approach extended from the early planning stages through construction to the as-built documentation of the completed project.

Keywords

BIM, building information modeling, design-build.

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