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A Virtual Success

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Using BIM, combined with lean construction techniques, results in enhanced field productivity for a California medical campus project.

WHEN IT COMES TO OVERALL PROJECT COMPLEXITY, FEW MARKETS RIVAL HEALTH-CARE. Intricate medical gas systems and the vast mechanical, electrical, plumbing, and fire protection systems needed for acute care facilities and many medical office buildings require project teams that are highly experienced and knowledgeable in this specialized market sector. In California (and other states), design and construction teams also must navigate a cumbersome regulatory environment for hospital projects, overseen by the Office of Statewide Health and Planning Department.

Additionally, the current boom in California's health-care market—driven by a state law that has set graduated deadlines for hospitals to comply with current seismic standards by 2008 (or 2013 if an extension has been granted) and even more stringent standards by 2030—has further stretched resources, severely limiting the pool of qualified subcontractors. And, owners' demands for their projects to be brought to market faster than ever, to meet their own customers' needs, adds yet another layer to the complexity.

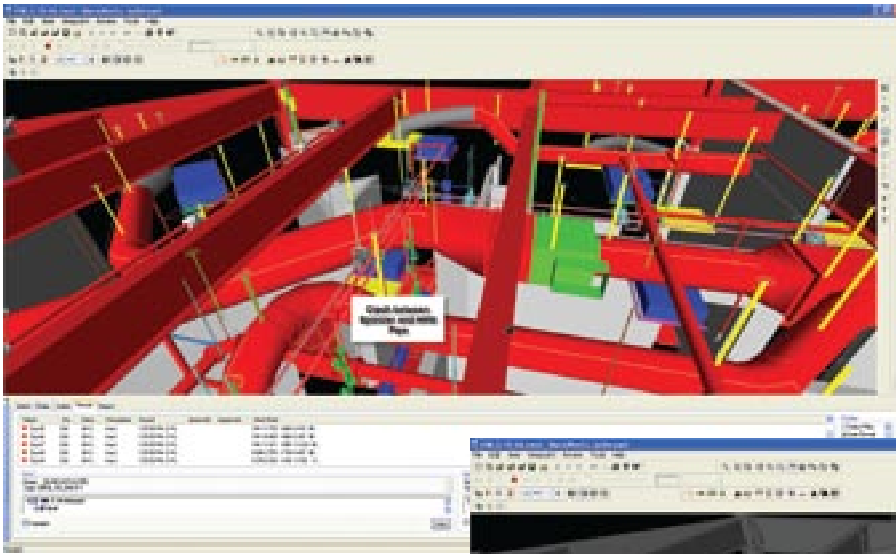
One trend helping to ease the challenges of project delivery is that of traditional 2D drawings and light tables being replaced with robust building information modeling systems. By modeling the design and construction process in 3D and 4D before construction actually begins, BIM enables teams to resolve clashes in building systems before they ever get to the point of field installation, and has proven particularly helpful in the design and installation of the highly complex mechanical systems found in health-care facilities. Virtual design and construction is also helping project teams achieve a far greater level of prefabrication on their jobs, leading to shortened field installation times and improved productivity and safety, among a host of other benefits.

Building Better with BIM

The combination of BIM and lean construction techniques is a powerful one; the idea of "lean construction" centers around maximizing value, increasing productivity, and reducing waste throughout the project delivery process. A great example of what can be accomplished when a team employs this combination is a newly opened, $98 million medical campus in Mountain View, Calif. Completed in March, the Camino Medical Group medical office building project included a 250,000-sq.-ft medical office building and a 420,000-sq.-ft parking structure.

As with a majority of large-scale medical facilities, steel was selected as the structural system for this project. Special moment resisting frames (SMRFs) and special concentric braced frames (SCBFs) were used for the lateral force resisting elements. This combined system helped keep the overall steel weight and costs down and also allowed for more open and flexible work space plans. The structural steel skeleton also served as a key element of the overall virtual mechanical systems coordination in 3D.

The project was completed in March, an estimated six months earlier than would have been achieved using the traditional design-



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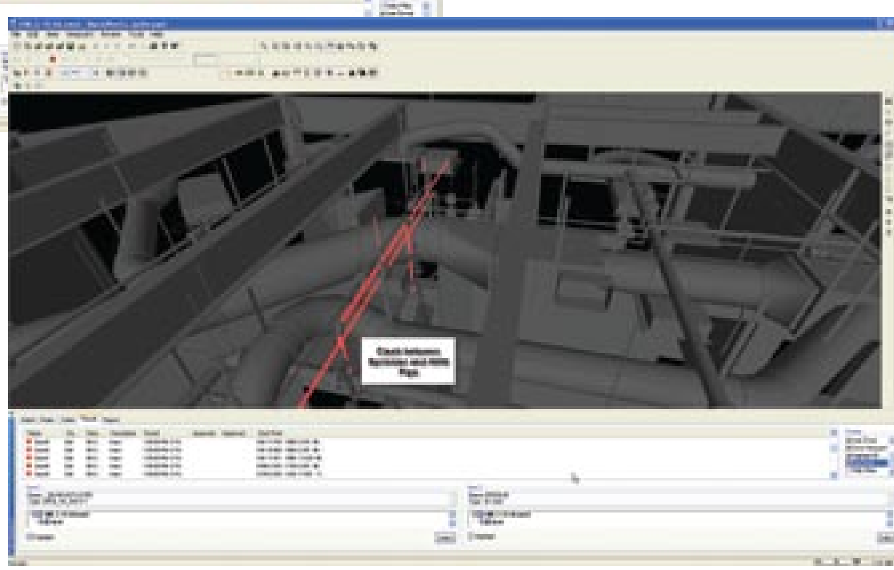
Based off the structural drawings, the 3D model also included the building's mechanical systems.



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Clash-detection routines highlighted instances of interference between the various building systems, including the structure.

bid-build project delivery method without BIM and lean techniques. The owner's primary goal of shortening the overall project duration—in order to have the facility operational as quickly as possible—meant that the team needed to start construction before the design was complete. The general contractor, along with the key mechanical subcontractors, came on board very early in the design process with the structural engineer and architect. They formed multidisciplinary teams of designers and contractors, who worked together to model and coordinate building systems on computers located in an open office area of the field office complex called the "Big Room" before breaking ground on site.

Collaborate, Really Collaborate

A strong collaborative environment was cultivated on the Camino Medical project. The spirit and enthusiasm to drive true change, shared by all the major players, helped to overcome the lack of experience some parties had in using 3D modeling tools and lean construction processes. Co-locating the design and detailing teams in the Big Room, where detailers worked side by side to construct designs virtually and were able to resolve conflicts and issues immediately, further facilitated a highly integrated project delivery. The detailers used shared resources, including a network server, printers and plotters. All the construction documents were generated from this one room. Weekly meetings were held to review progress and analyze and correct clashes using the 3D model.

As with all BIM projects, the Camino project team also addressed a number of questions from the beginning to guide the project coordination process, including:

- How should the project be organized to best implement BIM?
- What roles should each project team member play in the coordination process?
- What common protocols should be established for the technical logistics of the coordination process (i.e., establishing how files would be shared and updated, etc.)?
- What level of detail should be included in the architectural, structural, and mechanical models?

From the outset, the team determined it would use BIM for the coordination of mechanical systems. The steel, modeled in 3D by the structural engineer, formed the foundation for the coordinated 3D mechanical systems model.

Lessons Learned

One of the key lessons from previous projects in the 2D world was that the structural model should include connections like gusset plates for the SCBF connections. The Camino Medical 3D model did show all of the gusset plates, but they were based on the structural engineer's design and not the actual steel-shop-fabricated gusset plates. While this disconnect did not cause any issues on the Camino project, the possibility of field clashes will remain at large gusset plate connections until a direct digital exchange exists between the structural steel detailer and structural engineer.

Models should also feature all the miscellaneous metal supports and connection points to external building elements like façade panels and medical equipment supports. All of these details play a crucial role in the modeling of mechanical systems. The lack of detail of some of the objects proved to be the sole source of field errors, where clashes had not been detected by the model. This clearly illustrates the need for structural engineers, steel detailers, and steel fabricators to work toward greater integration.

It also became clear that it is far more preferable to initially model in 3D than to convert a 2D drawing to 3D. Converting 2D models to 3D after the design is largely completed caused some issues, as design changes required a significant amount of additional detailing effort.

While the use of BIM and lean construction requires more time and involvement from contractors much earlier in the process than usual, the payoff comes in greater value achieved during construction. Savings on the Camino Medical project were accrued through a significantly higher level of prefabrication of mechanical components, the elimination of conflicts between the various systems, reduction in change orders, and an increase in field productivity due to reduced field conflicts.

Exceptional Results

In the end, despite some issues working through inexperience with 3D modeling and a few minor field issues, the Camino Medical project remains an unqualified success of what can be accomplished through a collaborative virtual building process:

- Labor productivity was 15% to 30% better than industry standards.
- Less than 0.2% re-work was required on the HVAC system.
- There were no change orders related to field conflict issues, and only two field issues related to RFIs.
- There were no field conflicts between the systems that were modeled and coordinated using BIM. Normally, on comparable projects, an estimated 100 to 200 conflicts must be resolved in the field using traditional coordination methods.

Clearly, the use of BIM technology and the lean construction methodology proved important to overall project success. Equally important, however, was how the team used those tools within the context of a highly collaborative environment, establishing overall goals, developing models, and gathering and sharing information to create a breakthrough in enhanced project delivery. MSC

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