BIM and the Building Facade

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Facade TecNotes Series

enclos corp

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and the
Building Facade

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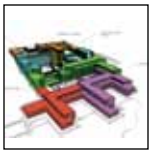
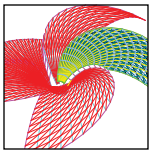
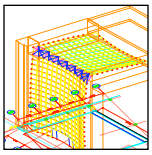






Enclos can provide complete turnkey solutions to your most challenging facade requirements, regardless of size, complexity, product or building program considerations. We are highly experienced in the varied special conditions involving commercial construction, ranging from design through site installation, and including both BIM and LEED qualifications.

BIM and the Building Facade

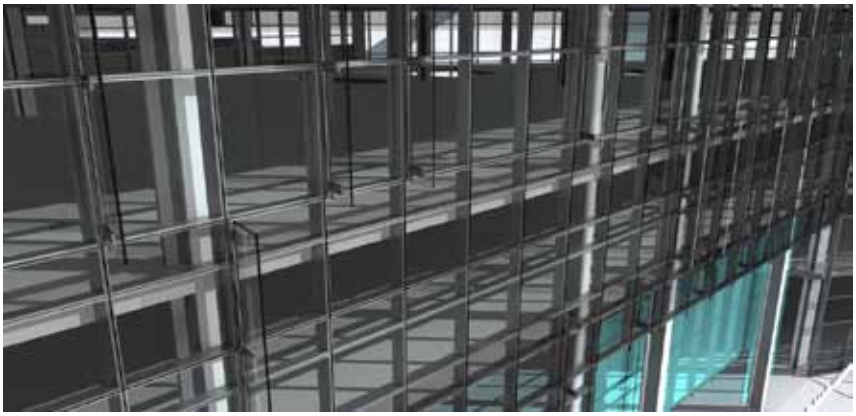
Executive Summary

Enclos Corp is a provider of custom, engineered-to-order (ETO) facade systems, with a scope typically ranging from early concept development through installation. As both early adopters and developers of the new curtainwall facade technology that emerged in mid-twentieth century America and Europe, we have been aggressive in engaging emergent technology since that time. Building Information Modeling (BIM) is no exception. Recognizing the opportunity presented by the BIM process, the firm made a corporate level commitment to BIM in 2007, launching an initiative to adopt the technology and related practices, adapting them in the process to the unique context of the building skin. Enclos is now leading the field in the application of this emergent technology to all aspects of the building facade, from concept development through fabrication, delivery, and installation.

The adoption of BIM and virtual construction technology by the AEC industry has been accelerating. Digital 3D building models are created and shared by multiple entities to design, build and manage projects more efficiently. The use of BIM has demonstrated favorable impact on both design and construction phases of projects, improving quality, lowering costs and reducing schedules. This has been evidenced as especially true when the project team involves specialists early in the design process, creating a collaborative environment where the impact of design decisions on a project can be accurately simulated early on. Enclos has been frequently involved in a large number of such projects, long before the development of BIM technology, because of its experience with advanced facade technology in highly custom building designs. Such involvement has typically occurred under a design/build or design/assist delivery strategy. This collaborative process has migrated to a broader application and emerged under the moniker of Integrated Project Delivery (IPD). IPD with BIM at its core is redefining the construction process, providing increased value to all stakeholders.

The building skin is central to these developing processes because of its effect on both building performance and appearance. This report explores the increasing integration of BIM with the design, manufacturing and management practices of Enclos operations, both as they relate to our internal use and as the services we provide our clients. Advanced facade and skylight systems present unique challenges to their integration in a building model. Glazing systems are primary expressions of the building's character. Complex geometry, tight operating tolerances, precise joinery, demanding performance requirements, and key aesthetic considerations, combined with a typically large inventory of components and component types, require special expertise in the use of BIM tools for building enclosures.

This document begins with a brief description of Enclos technology. It then reviews the various processes and software tools that comprise the collaborative BIM process at the company. It concludes with a few select case studies highlighting the use of 3D related process on past projects.



Service and Technology

Enclos is an engineered-to-order (ETO) custom facade system provider with a typical scope of work ranging from concept development through installation.

Enclos is expert in the design, engineering, fabrication, assembly and erection of custom curtainwall systems and structural glass facades, providing complete design/build services to the construction marketplace.

We specialize in innovative architecture and challenging building projects. No project is too large, no building site too difficult for our seasoned operations teams. Our work experience includes many projects with specialized materials, complex geometry, and innovative structural and mechanical system designs. Enclos curtainwall and facade systems
incorporate state-of-the-art materials and performance.

The attributes most appreciated by our clients however are our site management capabilities and our track record of meeting demanding project schedules.

Custom Curtainwall Systems

Enclos offers the most innovative curtainwall systems in the marketplace, combining aesthetic, performance and economic considerations into optimum solutions to our clients' needs. Our inventive unitized systems have evolved through their application on numerous major building projects to represent the state-of-the-art in curtainwall technology and performance. Sophisticated system design features and installation methods have paralleled this evolution, resulting in improved economy as well as superior performance.

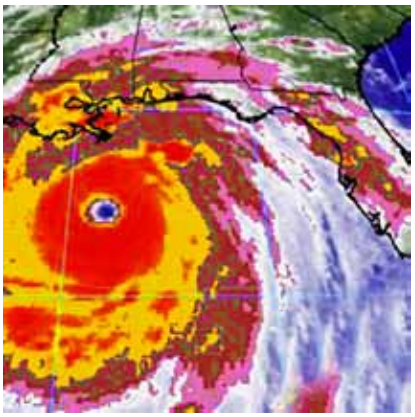
Structural Glass Facade Systems

The integration of glass and structure is a predominant attribute of this expressive building form, often employed to maximize transparency in large public spaces. Enclos has played a leadership role in the development and application of this cutting-edge technology, including a range of structure types:

- cable nets
- cable trusses
- long-span truss systems
- grid shells
- spaceframes
- all-glass structures

Our glazing systems include point-fixed types in both bolted and clamped versions,
as well as framed system types, all custom designed in response to specific project requirements. For more information see the section titled, Structural Glass Facades
and Enclosures.

Security Systems



An aggressive and ongoing research and development program has resulted in systems and products designed for special applications. Among these are the following:

- hurricane products, designed and tested
  in conformance with the South Florida building codes
- security and blast systems
- acoustical wall systems, for those applications with acoustical performance requirements beyond those normally
  specified
- fire and smoke testing
- enhanced thermal efficiency
- composites, advanced materials, smart materials and systems research
- advanced facade systems, double skin facades and smart facades

Design and Engineering

Enclos services have proven especially effective in any building program including innovative content in the form of advanced design, materials, systems, or installation methods, and in programs incorporating BIM and LEED. We provide comprehensive design-assist and design/build services as appropriate for integrated project delivery (IPD).

The foundation of a successful facade or curtainwall project is innovative system design and engineering. Our D&E group develops custom solutions to each new project, derived from a robust framework of Enclos technology and know-how. Design considerations range from the aesthetic and performance requirements determined in collaboration with the architect, to the fabrication and installation requirements that must be anticipated by the system design to assure a successful project completion.

With an in-house design group over 100 strong and a long history of experience in the design and development of custom curtainwall and advanced facade systems, Enclos provides unparalleled design service to the AEC industry. From concept development to the BIM facade, from virtual construction to multiple facade simulations, the Enclos design team has the experience and expertise to deliver comprehensive engineered solutions to the most challenging facade program.

In addition to 3D modeling and BIM, the Enclos team can provide analyses ranging from finite-element analysis (FEA) to computational fluid dynamics (CFD). Our advanced visualization and simulation capabilities have also proven valuable to both the design and build teams of our diverse client groups.

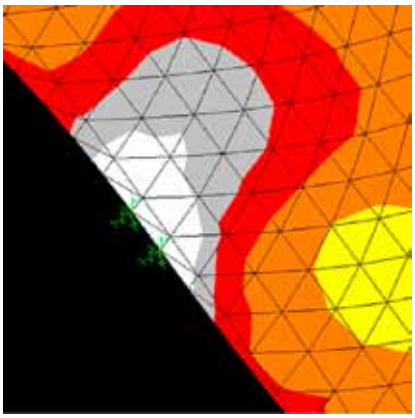
Conceptual Design

The ultimate success of a challenging building program is often rooted in the conceptual design. The decisions made, or not made, during concept development, can have enormous impact as the design and construction progress. This is also the time when the design team is often working with the least information.

Alternate project delivery strategies have developed for this reason. Design/build and design/assist programs can be structured to accommodate the early involvement of a specialty subcontractor so that critical input can be provided to the design team when it is most effective in terms of preventing future problems. More recently, integrated project delivery (IPD) has emerged as a most promising delivery strategy. A highly collaborative process, IPD emphasizes involvement of specialty providers early in the concept development stage of a project.

Enclos has been delivering innovative facade solutions for decades, and has frequently participated in the concept development process with many of its clients.

3D Modeling and Form-finding

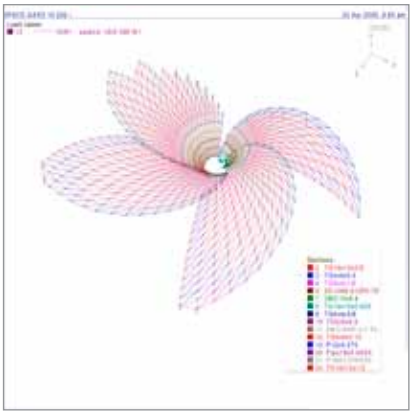


As a provider of innovative curtainwall systems and structural glass facades, the Enclos design team is frequently involved with complex building form and surface geometry. In support of this work, the company has developed an extensive expertise in 3D modeling and advanced form-finding techniques.

AutoCAD 3D, Sketchup and Rhinoceros are frequently used by the team, depending upon the magnitude and nature of the task at hand. The 3D models often migrate between platforms. We have found it more efficient in some cases to develop a model with one of the above programs and then import it into Revit Building. Our clients sometimes import the model into other BIM software. On the other hand, some models may be easier to construct directly in a BIM modeling software.

Internally, the 3D model is used at Enclos for everything from cost estimating and fabrication programming to installation planning and coordination.

Structural Engineering

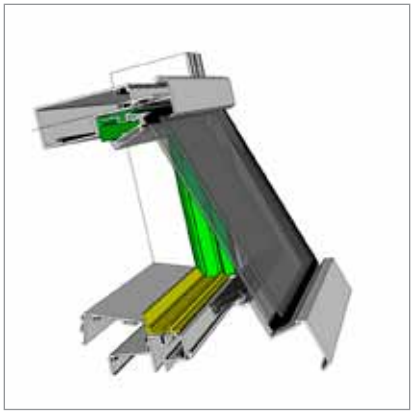


Enclos employs 13 structural engineers, with licenses in 29 States, including structural certifications in California and Illinois.

Enclos is expert in the traditional design associated with building envelopes, such as wind, thermal and snow loads, and building movements (including seismic). But the design capability only begins here. The firm has evolved the expertise to perform non-linear analysis as required to support advanced facade designs, including blast design and cable structures. Enclos uses STAAD as its 3D static analysis software along with pre-programmed Mathcad templates for component design. FEA and non-linear analysis are supported by Strand and SpaceGASS.

Recent in-house research resulted in advancements in theories related to the deflection of thin plates, load sharing and pressure equalization models for spandrel and shadowbox cavities, as well as advanced component design for wall systems in hurricane zones.

Facade Systems Analysis



A remarkable aspect of the building skin is the number of performance attributes associated with it that can so impact overall building behavior, ranging from user comfort to energy consumption. Armed with a building model, a plethora of innovative software programs, and many years of experience, the Enclos engineering team can provide a wide variety of analysis on the building facade beyond structural, including:

- thermal: Therm, Window
- acoustical: proprietary
- daylighting: Radiance, 3D Studio
- ventilation and convection: Flovent, ANSYS CFX
- energy and climate: Ecotect, Climate Consultant

We are constantly exploring new techniques that can further inform the facade design process and result in higher performance building skins.

Simulation

Some of the analysis programs discussed elsewhere are also simulation programs. The Enclos design and engineering team employs a variety of analytical and visualization tools and techniques to create various simulations of building behavior. We also develop simulations to illustrate processes, with installation method prime among them.

Site constraints and installation concerns can become a predominant issue from the very beginning of many building projects. Our site operations teams have consistently developed innovative solutions to a wide variety of unique site and construction requirements. Our ability to demonstrate these solutions, even, on many occasions, during the pre-award phase of a project, has proven a valuable aid in site planning and logistics, and in facilitating coordination between subcontractors.

Project Delivery

Managing the project delivery process is the core strength of Enclos, something at which we excel beyond all our competition. This capability provides us consistent control over the vital requirements of schedule, quality and cost, and allows us to consistently deliver top quality economically and on time. This capability is the basis for our many long term relationships with developers, general contractors and architects.

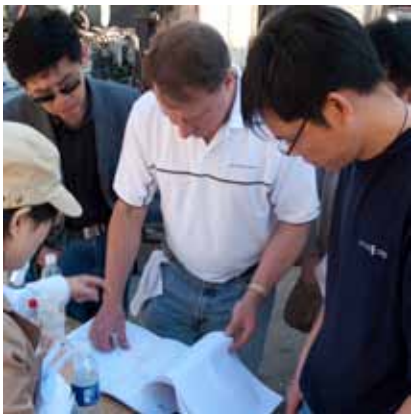
Each new project undertaken by Enclos is treated as unique, and a custom delivery strategy is developed in direct response to the singular set of considerations presented by the project. This custom strategy, however, is developed through a uniform process unique to Enclos that embraces the spectrum of activities from pre-construction through design, engineering, procurement, fabrication, assembly, and erection. This process, developed and refined through the successful completion of hundreds of remarkably diverse facade and curtainwall installations, serves to mitigate the inherent risk of a challenging building project by enhancing the predictability of performance, schedule and cost.

3D, 4D, and BIM

The General Services Administration (GSA), the nation's largest property owner, distinguishes between three related but distinct processes. The 3D building model is a digital representation in three spatial dimensions. 4D melds the dimension of time to the 3D model, which can be particularly useful in examining installation methods, construction phasing and activity scheduling, and site logistical planning. 5D introduces the dimension of cost. The rapidly emerging process of BIM combines a virtually unlimited quantity and type of information with the 3D model.

In working with complex building form and advanced surface geometries over many years and on a wide variety of projects, Enclos has developed an expertise in 3D modeling. This has provided a solid foundation for the adoption of BIM. We are participating in projects where BIM is being employed as a collaborative process for design and construction, and have assembled extensive component families for inclusion in building information models.

Project Management



Project management is an empowered function at Enclos Corp, and key to our success. Personnel skilled and experienced in project management are vital to the success of any construction project. Our project management teams lead design development, production engineering, fabrication and assembly, and field operations, bridging these various activities to form an organized, unified continuum of project development throughout the design and build process. Enclos project management personnel receive extensive training and years of on-the-job experience before being appointed to the position and entrusted with the responsibility of running their own projects.

Our people understand the critical importance to a building project of on-time, on-budget performance, a fact which our past clients can best attest to. We will happily provide you with such references.

Fabrication

Curtainwall fabrication and assembly is a critically important part of the project development process. Enclos Corp maintains dedicated manufacturing operations in key geographic locations capable of providing fabrication services for the most complex designs and the most challenging project schedules. Our facilities incorporate state-of-the-art equipment and processes for curtainwall unit fabrication and assembly. In addition, to provide adequate capacity for the fluctuating demands typical of the building marketplace, we have developed a network of outside fabrication sources. These partner fabricators and material suppliers have been rigorously trained and qualified in relevant aspects of Enclos curtainwall systems, and all have successfully provided services on prior Enclos projects.

Supply Chain Management

Our global supply chain is a significant corporate asset that we provide to our clients, who receive the benefit of the most competitive possible cost independent of the fluctuations of local market conditions. Global economies, currencies and markets are shifting faster and more dramatically than ever before. In order for domestic firms to provide optimum solutions to their client's needs, it is mandatory that they be able to procure materials and services from any global market providing the best combination of quality, lead time and cost.

Recognizing this, Enclos Corp launched an initiative in 2002 to develop its nascent network of key suppliers into a world class global procurement machine. Enclos has successfully provided project materials and services from diverse areas of Europe and Asia on dozens of domestic projects, saving our clients many millions of dollars in the process. In circumstances where domestic supply is a requirement Enclos has both its own dedicated manufacturing facilities and qualified domestic suppliers.

Quality Assurance

Design or material supply problems surfacing in manufacturing are a frustrating and costly annoyance; design or manufacturing problems surfacing on the building site are a disaster. There is far too much at stake in the building process to settle for anything less than top quality and the programs that consistently deliver it. Effective quality programs garner the participation of everyone in the organization from top to bottom while reaching throughout the web of company operations and activities. We have developed and refined our quality assurance and quality control programs over the span of many years and through hundreds of diverse project experiences; another way that our deep experience works for you. These programs are robust and all embracing, ranging from management systems and procedures to the minutia of in-line quality verification processes. In addition, we develop a specific quality plan for each new project based on an analysis that identifies and accounts for any unique aspect of the project whether it be material type, location, site condition, performance requirement or design detail.

Site Operations

Enclos has been awarded many projects over its competitors because of a reputation for performance on the building site.

Everyone involved in the construction process knows the critical importance of the building site, the playing-field for the contracting teams. This is where the myriad complexities of a construction project converge and coalesce into architecture. The building site must be a particular focus for systems such as the building skin, where a large part of the process takes place off site; design, engineering, fabrication and assembly all precede the delivery of material to the site and the commencement of field installation. Yet the site is where all must come together. These preceding activities must be accomplished with a keen eye to the site, anticipating unique site-specific requirements and developing effective installation strategy to assure optimum performance. Poor performance by a single contractor can disrupt an entire building site.

Field operations are a core strength of Enclos Corp, and the attribute for which we are most widely recognized by the building community.

Our performance on the building site mitigates risk for both the design and build teams. This core strength has proven an effective tool in helping architects realize their design intent while staying within a determined budget, in assisting general contractors in controlling the building site and maintaining project schedules, and in providing owners a top quality building coupled with the economics of efficient delivery.

Field Operations Teams

The Enclos field operations teams manage our site operations across the country. They begin their project involvement in collaboration with the pre-sales design and estimating team, assisting in analyzing the site, determining installation strategy and preparing for the project bid. On new contracts they continue this involvement by coordinating installation requirements through all pre-installation activity: design, engineering, fabrication and delivery.

Our experienced and talented project managers and field supervisors undertake comprehensive installation planning and the development of a unique strategy carefully tuned to the specific requirements of each project and building site. They are in constant motion visiting active sites on a regular basis, monitoring progress and looking for opportunities to expedite work.

Pre-planning and Installation Strategy

Our people understand the building site. Enclos Corp has secured many of its projects on the basis of a clear and convincing installation strategy. Constrained urban sites with ambitious building programs present perhaps the biggest single challenge in the entire building process. Virtually every aspect of the facade design must be considered with respect to the building site, with many design decisions ultimately constrained by the realities to be encountered there.

The success of Enclos as a provider of curtainwall systems for some of the most ambitious building projects in history results in large measure from the ability of the firm to design, engineer, fabricate, assemble and deliver a product in support of a superior installation strategy, a product that goes together faster and cheaper on the building site. This is not simply a matter of a good anchor detail; it is a function of advanced system design, delivery sequencing, material handling, crew rotations, equipment usage, and the minutia of planning and scheduling amidst the remarkable complexity of a demanding building site.

Union Field Personnel

Enclos Corp is proud to have a long and productive relationship with both the ironworker and glazier unions. Through offices located across the United States, Enclos has established lasting connections with ironworkers and glaziers in each region. We manage our field operations through a mobile group of national superintendents, and with national support we train our field teams, ensure compliance with best practices, promote safety and quality standards, and coordinate with labor unions.

Our talented union crews most effectively differentiate us from our competition on the building site.

Safety

The safety of our people is of paramount importance, and we endeavor to be most rigorous in our safety planning. Enclos Corp has embraced a Zero Accident philosophy as represented by the Construction Industry Institute. We have a comprehensive site safety plan, and institute and manage a project specific safety program for all of our employees and subcontractors. The program consists of training, weekly toolbox meetings and careful site evaluation prior to the commencement of work activities. Our safety program includes the following practices:

- preparation of a site-specific safety plan for each project
- inclusion of safety training as a budget item in project bid preparation
- top management participation in investigation of recordable injuries
- provision for anonymous disclosure of unsafe conditions or behavior
- assurance that every worker receives a minimum of 4 hours per month of safety training
- each safety professional serving a maximum of 50 site workers

BIM Power

Enclos experience with BIM encompasses the interface with and joint development of a project building information model initially developed by others, the development of our own BIM models using Revit Building or other BIM compatible 3D modeling software, the development of a library of intelligent components for our facade systems, and the integration of internal operational processes with the BIM process.

There are many potential users of and uses for a building information model. Some projects still do not use BIM at all, while others integrate it throughout the building process from concept design through the entire building lifecycle. As Enclos has moved to develop its internal BIM practices, we have made every effort to keep these as adaptive as possible to the wide variety of individual project needs.

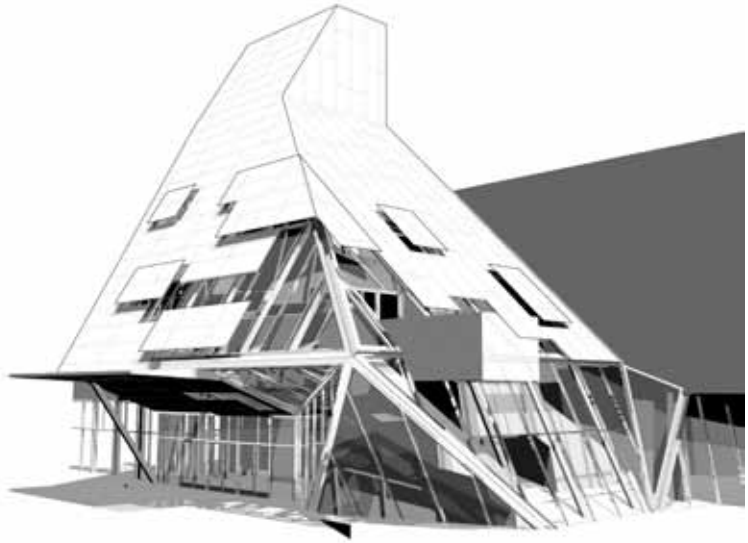
Our adoption of BIM is a natural evolution from the foundation of software tools and company-wide operational practices acquired or developed over past decades. The company's success has long been based on values and initiatives such as teamwork and collaboration, early participation in design development, and the application of processes insuring predictable quality and schedule despite highly innovative content. Accompanying this, the firm has long experience and expertise in the use of 3D design and analysis tools, and 4D and 5D management tools.

Long before the adoption of BIM by Enclos, applications such as AutoCAD were customized using ARX programming language interface to create project databases, supplying design teams with libraries of components such as aluminum extrusions and gaskets, and providing component nomenclature for factory and field crews. These functions have naturally evolved to become part of the BIM process for the company's internal operations. The databases were used for everything from engineering and shop drawing, to procurement and manufacturing, and installation planning. These databases were often accompanied by a 3D model, if for no other reason than because the custom facade designs contracted by the firm demanded their creation for the purpose of structural analysis, although they were often used in support of the other activities mentioned above, especially installation planning.

BIM Platform

Enclos ultimately selected Autodesk Revit Building as its primary BIM platform to simplify crossover issues with Inventor and AutoCAD, two earlier adopted Autodesk design packages. The firm is also capable of interfacing with other BIM platforms. We have implemented the 2010 versions of Revit, Inventor, AutoCAD and Navisworks.

As a BIM software, Revit allows for intelligent, 3D and parametric object-based design. Revit incorporates a single file database that can be shared among multiple users. Plans, sections, eleva-



right: 3D model produced in collaborative effort with architect Coop Himmelblau. Rhino, AutoCAD, and MS Excel were used to model complex geometry and coordinate placement of anchor embeds.

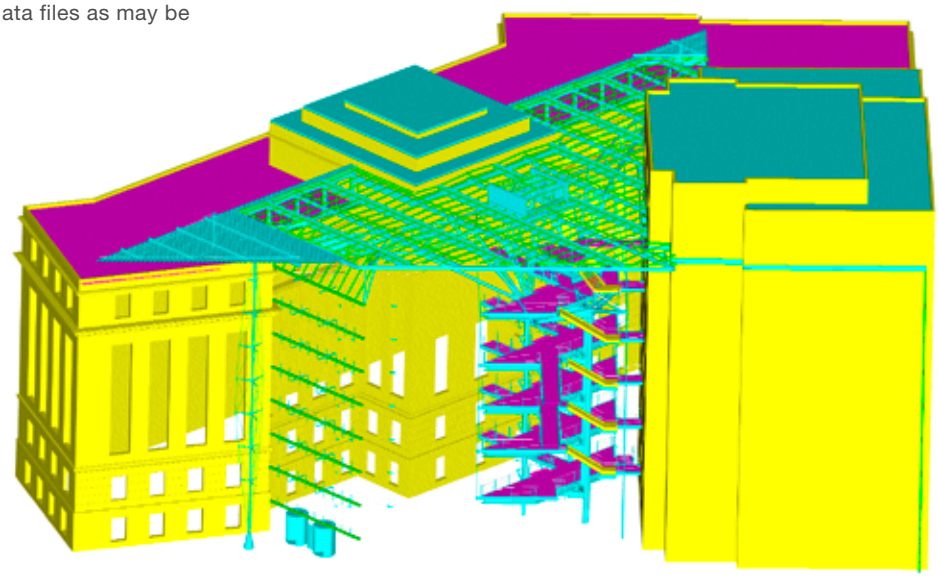
next page: BIM compatible model for project in Washington, DC with architect Richard Rogers. Atrium structure ties 3 buildings together.

tions, legends, calculations, schedules, and quantity takeoffs are all interconnected. Design changes to the model are immediately implemented in any view with updated associated data. This ensures that all drawings, schedules and quantities are fully coordinated. Small-scale details of building components are created by importing and linking AutoCAD 2010 files.

Enclos creates 3D models with the most appropriate tool depending on geometry and form finding requirements and integrates them with an object-based modeler, such as Revit, as appropriate. Curtainwall models are often created directly in Revit, or an existing model supplied by a project team may be imported. As above, plans, elevations, sections, and embed layouts are published from the model. Changes from the digital model automatically update 2D drawings or data files as may be required for fabrication, procurement or submittals.

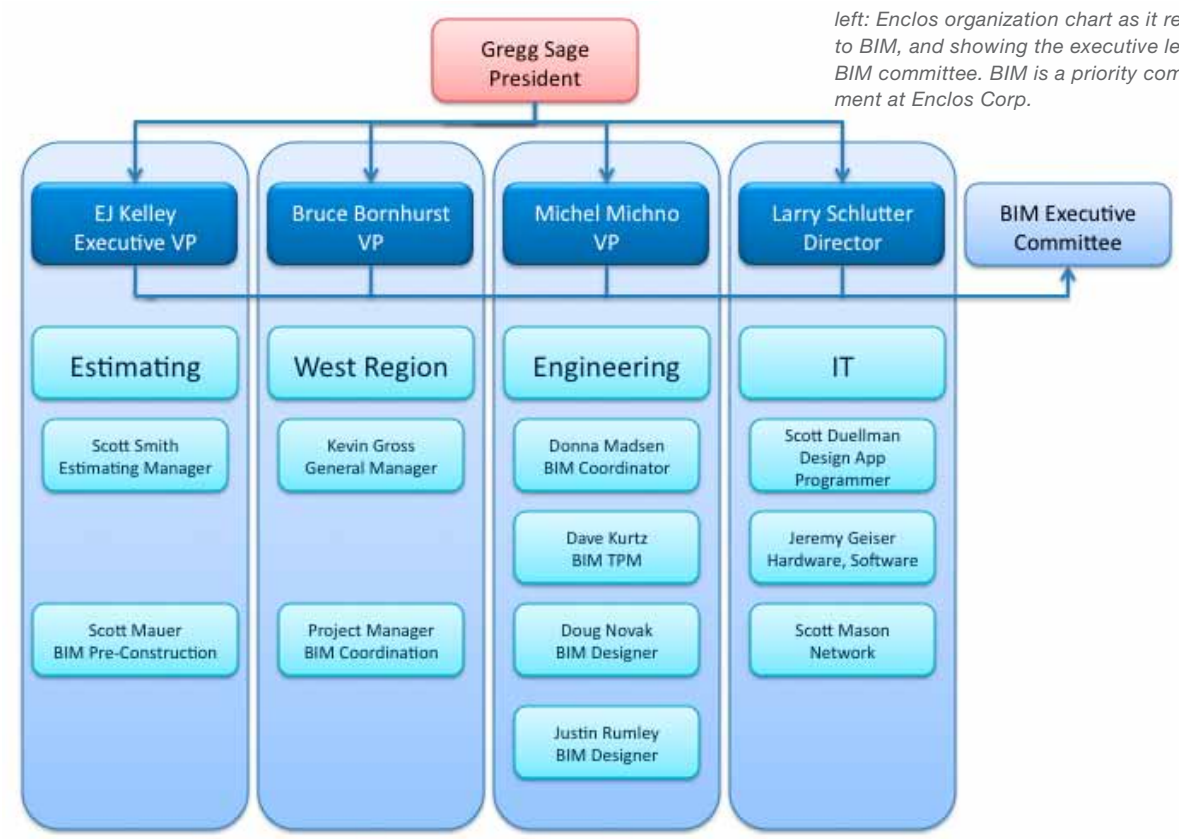
BIM facade components typically include glass, stone, and aluminum extrusions, as well as components interfacing with other trades. These components are kept to a reasonable level to not burden the project construction model, while allowing for future review and clash detection. Fine details such as screws, gaskets and sealants are published in AutoCAD and linked to the model. Sizes, quantities and types are extracted from the model in a format suitable to facilitate procurement. Databases issued from and linked to the model trigger the generation of parts in Inventor and subsequently feed Enclos' ERP proprietary applications, ESP and SIMS. Other engineering applications, such as structural and thermal software, use Revit, Inventor and AutoCAD models as required.

The Revit model is frequently transferred to Navisworks and combined with the Primavera schedule for coordination and planning purposes. Navisworks is used by Enclos for model review and time modeling. Autodesk Navisworks software combines 3D design models from other design tools such as Revit, in multiple formats that can be reviewed and analyzed as a single 3D project. Navisworks combines clash detection with 4D project schedules and 3D rendering, allowing construction simulation and improving design decisions and project planning. Enclos schedules its activities through Primavera Project.



BIM Organizational Structure

As many would-be adopters of BIM have discovered, implementing BIM involves far more than buying a software program, hiring a BIM technician , or even a BIM consultant. The BIM initiative at Enclos is headed by a top-level executive committee, effectively assuring implementation throughout the organization. The firm has a long history of best-practices, and the initiative is integrating these practices with the BIM process company-wide. This work is active and ongoing: testing, evaluating and integrating as appropriate the rapidly emerging developments of BIM technology. The company maintains an ongoing training program through Enclos University, an in-house educational resource, that includes programs in BIM and 3D modeling utilizing various software programs. Our team also includes a dedicated BIM coordinator.



left: Enclos organization chart as it relates to BIM, and showing the executive level BIM committee. BIM is a priority commitment at Enclos Corp.

BIM is Beautiful

While Enclos has developed its own internal BIM process that supports its facade work, project BIM requires close collaboration and full participation from all project stakeholders. Without this level of involvement, project BIM may not be appropriate for every application. BIM is emergent technology, and many are struggling with its use, and even questioning its value. Still, emerging BIM-centric, highly collaborative delivery strategies hold the potential to integrate the typically fragmented building process in a manner to benefit all stakeholders. These developments may well yield the greatest transformative force in building construction since the advent of the steel frame. We at Enclos are excited about BIM, and to be at the forefront of defining BIM and its application to the building facade.

Enclos recognizes the following benefits to its building envelope specialty from working on a shared BIM model:

Design: Using a digital model to visualize alternate designs during design development improves early decision making, as simultaneous work by multiple design disciplines and the integration of various models generated by these different disciplines along with clash detection, provides early insight into design problems and facilitates the incorporation of change. Conflicts are identified before they become a costly field problem.

Contract documentation: Overall contract documentation is improved. The use of a central model reduces the number of RFIs and becomes the central repository for test reports, quality records and maintenance manuals. The BIM is integrated with the corporate information management system.

Estimating: Pre-construction estimating is facilitated by generating accurate take-offs and bill-of-quantities from the BIM. This same facility is provided on an ongoing basis as the design evolves. Changes, addendums and revisions are automatically integrated.

4D and simulation: Integrating the element of time with the 3D model creates powerful planning, scheduling and schedule control capabilities. Overlapping activities and phasing issues can be explored through simulations. Crane placement, staging areas, shoring, and other relevant site requirements can be included as part of the simulation as required to fully communicate the intended methodology. During construction, actual progress is documented in the model. Enclos has used animations of the 3D model early in the design process, and occasionally even pre-award, to demonstrate intended installation method. These capabilities can significantly improve coordination with other trades.

The model can be used to perform analysis such as daylighting, thermal, acoustical, structural, and cost estimation at key points in the design and/or construction process.

Data from the model is used for component and assembly fabrication purposes. Such things as machining operations can be directly fed by data extrapolated from the model. The assembly of custom curtainwall units is facilitated by processed data from the model that becomes the fabrication work order.

Collaborative Design Process

The best way to get a sense of the deep collaborative process characteristic of Enclos is to talk with our previous clients (we will happily provide contact information on request). The company has been delivering both design and technological innovation to the building construction marketplace for decades. This cannot happen on every project. It is extremely challenging to deliver innovative content on a design-bid-build project because there is usually no mechanism for involving a specialty subcontractor like Enclos early enough in the design process to provide the necessary design support. Our clients, leading developers, contractors and architects, began exploring strategies to solve this problem.

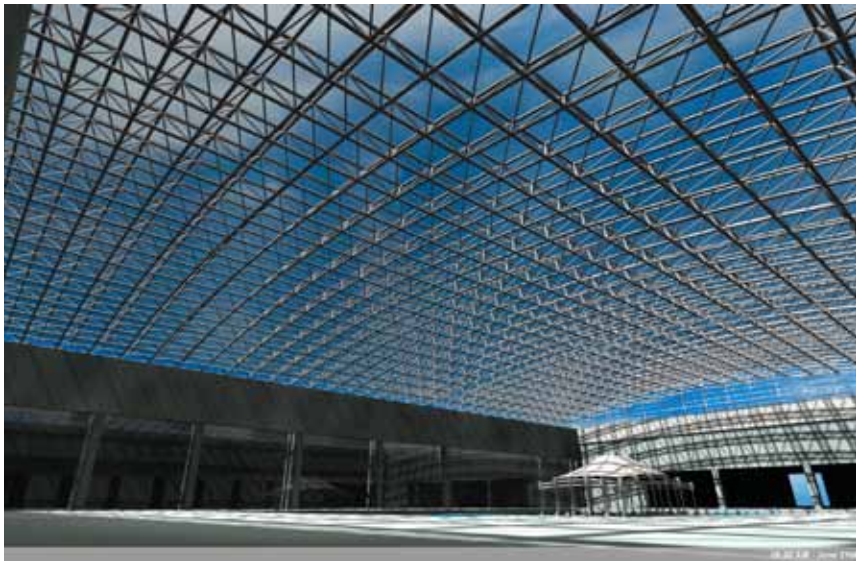
Even before design/build emerged as an alternative project delivery strategy, combining responsibility for design and construction in a single entity, Enclos was being summoned to participate with the design team under a contractual scope of work similar to design/build but limited to the building facade.

Implementing Innovation

This was particularly the case on building projects where innovative designs and materials were being introduced into the facade program. The general contractor would qualify appropriate facade contractors early in the building process, selecting one with a scope to provide full design, engineering and installation services. This allowed the specialty contractor to participate in the design development phase of the project, providing services and consultation as required to the project design team. Thus, Enclos is no stranger to the collaborative processes emerging from new practices such as integrated project delivery (IPD) and BIM. In fact, we have helped pioneer its use.

Information Integration

At Enclos, BIM is part of an integrated information environment, and the element frequently facilitating the integration. This is characteristic today of AEC industry firms at the forefront of adopting emergent BIM technology and practice. Individual programs and processes are merging in a developing



top: Concept development model for a custom glazing system using curved glass (Orange County Performing Arts Center).

right: A light study on a 3D model using Luminance software. A 3D model is useful for many kinds of analysis. This model was created in AutoCAD and rendered in 3DS.

BIM NOW!

BIM is slowly being embraced by the AEC industry. The large majority of projects Enclos contracts do not include a BIM program. Regardless, we usually develop our own 3D models, as we did with the Comcast project, as part of our design and engineering process. The model is invaluable in virtually eliminating errors in the design of curtainwall units, far more than justifying the cost of building the model. Accurate bills-of-material can then be derived from the model. The 3D model also facilitates installation planning and the sequencing of units for fabrication.

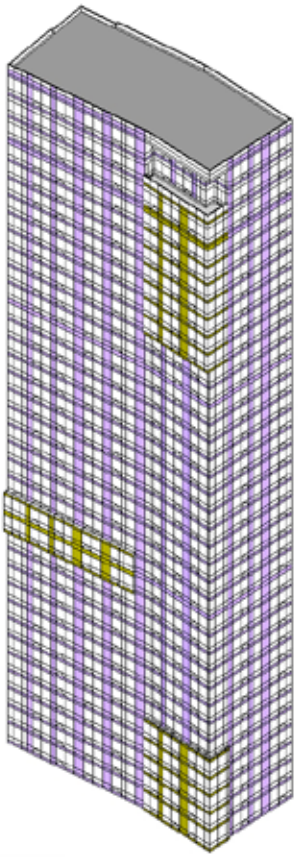
context of system interoperability that is slowly being embraced by the industry at large. Each of the different processes and supporting software tools provide unique functionality to the whole.

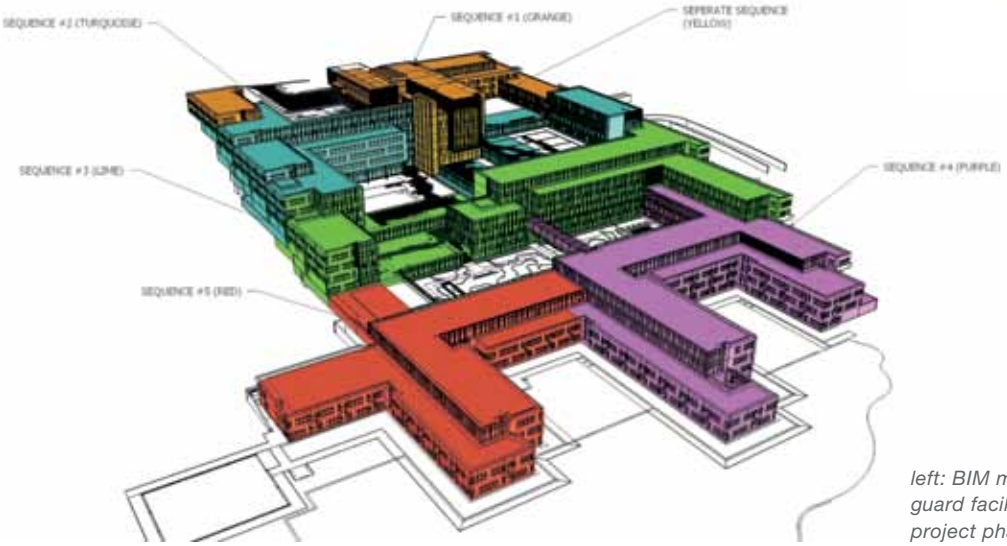
Concept Through Installation

As an engineered-to-order (ETO) component producer of advanced building facade technology, our scope of work on a building project typically ranges from early concept development through installation. Such a wide and varied scope of activities demands the development of refined processes and the use of a considerable variety of specialized software programs to comprise the overall information processing platform for the company's operations.

BIM is a not simply a software tool, but a process of project delivery. Software tools, however, are integral to BIM. The following section discusses the software tools used by Enclos in support of the BIM process.

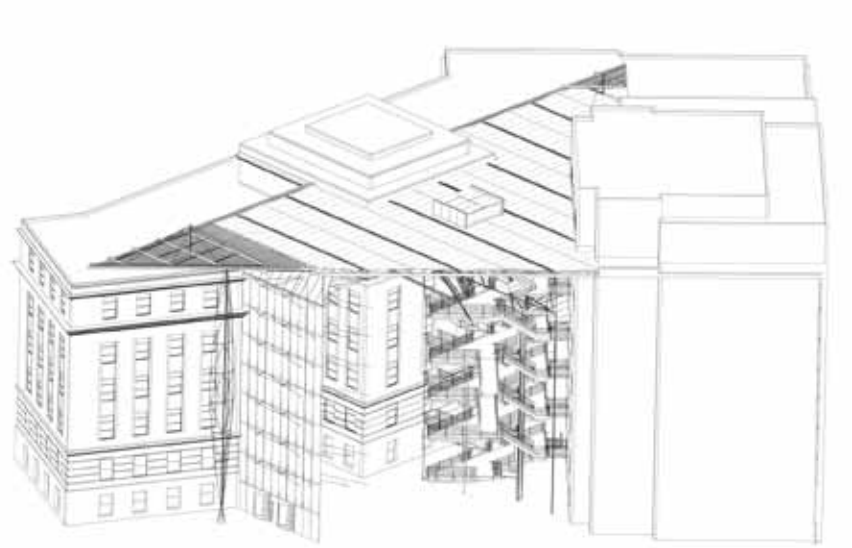
below: A 3D BIM compatible model built with Inventor and incorporating facade elements for the Trump Soho tower in Manhattan.





left: BIM model by architect of a new coast guard facility used by Enclos to show project phasing.

3D Modeling and Form-finding

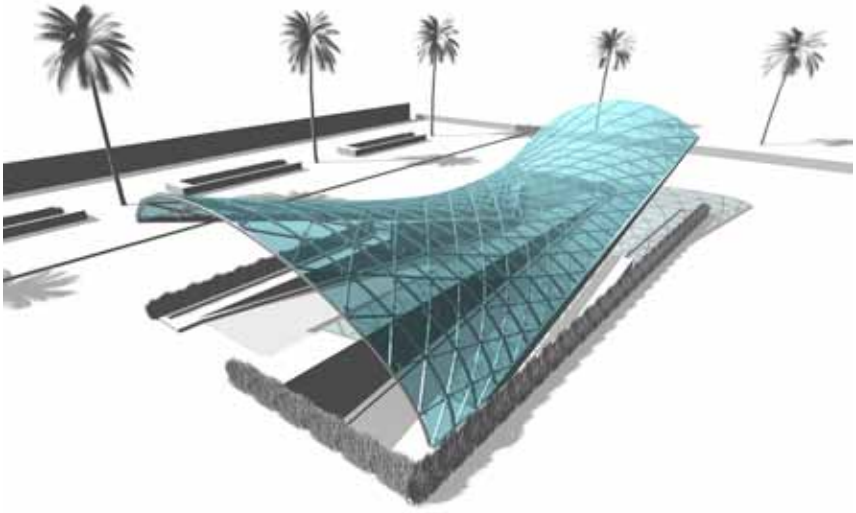


right: Enclos often models the entire building even if we are only doing a small part of the facade. Here a skylight and structural glass facade spans between three adjacent buildings, all of which have been included in the model.

Enclos has a design and engineering team over 100 strong. The team has decades of experience with advanced facade technology (faceted systems, double-curved surfaces, cable nets, grid shells, etc.) involving complex geometry and requiring sophisticated analytical techniques that can only be accommodated through the use of a 3D model. Thus the Enclos team of design professionals long ago developed the capability to model graphic and computational solutions to complex building geometry and surfaces. Forms and shapes are created and optimized according to algorithms based on precise tolerances, structural performance, manufacturability, sequencing, repetition and economic feasibility.

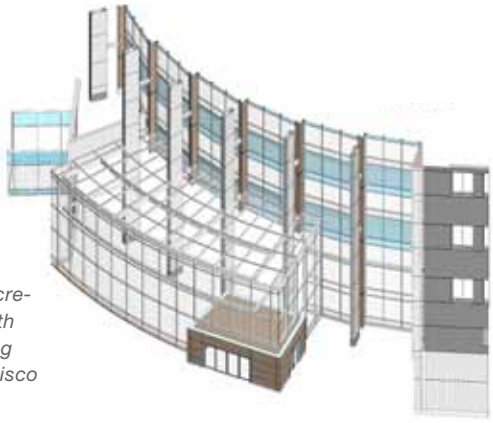
In addition to AutoCAD 3D, Enclos has used a variety of software tools. Sketchup is quite popular among architects, and provides for quick, simple models. Inventor generates accurate geometry and precise dimensional data directly usable in fabrication processes. Rhinoceros, a more sophisticated and flexible 3D modeler, can be used to create very accurate, advanced free-form surface and solid models.

Modeling in Rhino is different from modeling in Inventor and other parametric, feature-based modelers. Inventor starts with a sketch and then adds features to create a command history tree. Rhino does not maintain a command history tree and has no parametric features (plug-ins are available). This frees the designer to work directly with solids, curves, and advanced surfaces. All of these software tools have their place, and we use whichever is the most appropriate to the task at hand.



right: Complex double-curved surface models are first modeled in Rhino and converted to a BIM model as appropriate..

BIM Analytics



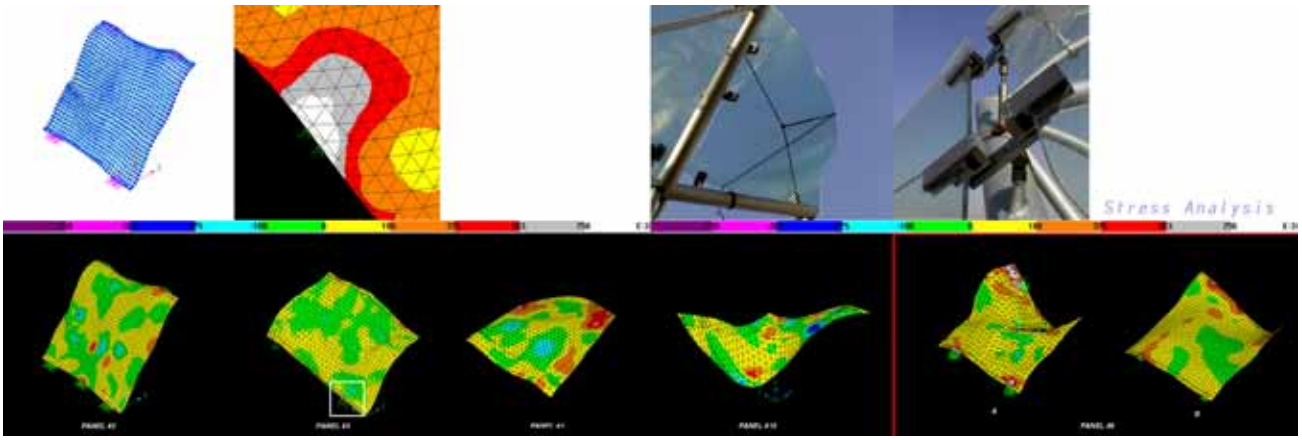
right: 3D models are used as input to create building information models, as with the BIM software Revit. (Model by Fong and Chan Architects for the San Francisco General Hospital.)

Enclos employs 13 professional engineers, with licenses in 29 States, including structural certifications in California and Illinois. Enclos is expert in the traditional design associated with building envelopes, such as wind, thermal and snow loads, and building movements including seismic, but the design capability only begins here. The firm has evolved the expertise to perform non-linear analysis as required to support advanced facade designs, including blast design and cable structures. Enclos uses STADD as its 3D static analysis software along with pre-programmed Mathcad templates for component design. FEA and non-linear analysis are supported by Strand and SpaceGASS. Recent in-house research resulted in advancements in theories related to the deflection of thin plates, load sharing and pressure equalization models for spandrel and shadowbox cavities as well as advanced component design for wall systems in hurricane zones.

BIM implementation at Enclos facilitates structural design. In the traditional 2D environment, wall systems are designed using representative areas of the project, and then tested in a full size mock-up to validate the design through deflection and movement analysis, and finally detailed calculations are performed along with the shop drawings. Modifications to the tested design are virtually impossible since shapes have been set through the approval process. Unanticipated conditions or changes to the project have to be solved using reinforcement, additional anchors and/or modifications of the building structure. This can result in inefficiencies, delays and additional costs. In a BIM environment, as-built conditions can be scanned and downloaded to analytical software. Complex geometry can be reused and does not have to be re-modeled. Early design changes are also quickly implemented. This allows structural engineering to perform more exhaustive reviews early for better optimization of the building enclosure. During the design-for-construction phase, using a centralized BIM enables concurrent engineering and detailing.

Enclos' process of linking Revit and Inventor also allows engineers to reuse solid models of parts and assemblies for finite element analysis and simulation.

below: Complex surfaces are mapped using parametric modelers and then the panels are subject to finite element analysis.



Fabrication and Parametric Design

For the production of fabrication drawings, Enclos uses the Autodesk Inventor platform. Inventor is a parametric solid modeling design software. Stress, deflection, and motion, as well as fit and assembly can be simulated. In Inventor, intelligence built into the components enables design automation. Data extracted from building geometry models designed in Revit automatically generate fabrication drawings.

A substantial portion of Enclos design work is related to unitized curtainwalls. Using this case as an example, the fabrication drawing is as follows: 2D sketches of die shapes and gaskets are generated in Inventor or AutoCAD Mechanical. Rules and constraints are programmed in the Inventor sketches to govern future behavior of the shapes. Sketches are then used to generate generic extrusions. Extrusions are then turned into parts, using a set of rules.

For example, the position of a mullion in a unit can be related to the horizontal unit module, and its length to the vertical module. Horizontal shapes can be linked to mullion surfaces and vertical modules. Machining operations, fasteners and hardware are associated to profile intersections. All extrusions, glass, infills, gasket and sheet metal are entered with variable parameters. Generic 2D drawings (.idw) are created and linked to the generic parts. Future changes to parts are reflected automatically in the drawings. Data issued from the Revit model such as module dimensions, unit type, unit geometry, glass type, and finish is linked to the generic unit drawings so as to automatically produce solid models of parts and associated 2D drawings. Parts data is further managed in Enclos' proprietary ERP system.

New Campus East - Atrium
STEEL ANCHOR PARTS
Plan Report

Plan #	Parts	Part Qty
AL300	SAFS51-1000A	26
	_FS51-1000A	1
	SAFS51-1001A	24
	_FS51-1001A	1
	SAFS51-1002A	2
	_FS51-1002A	1
AL301	SAFS50-1000A	23
	_FS50-1000A	1
	SAFS51-1000A	32
	_FS51-1000A	1
	SAFS51-1001A	30
	_FS51-1001A	1
	SAST79-1000A	23
	_ST79-1000A	1
AL302	SAFS51-1000A	30
	_FS51-1000A	1
	SAFS51-1001A	28
	_FS51-1001A	1
	SAFS51-1002A	4
	_FS51-1002A	1
AL303	SAFS51-1000A	19
	_FS51-1000A	1
	SAFS51-1001A	17
	_FS51-1001A	1
AL400	SAFS50-1000A	16
	_FS50-1000A	1
	SAFS50-1002A	44
	_FS50-1002A	1
	SAFS50-1003A	4
	_FS50-1003A	1
	SAFS50-1003B	2
	_FS50-1003B	1
	SAST79-1000A	16
	_ST79-1000A	1
AL401	SAFS50-1000A	57
	_FS50-1000A	1
	SAST79-1000A	57
	_ST79-1000A	1
AL402	SAFS50-1000A	41
	_FS50-1000A	1
	SAST79-1000A	41
	_ST79-1000A	1
AL403	SAFS50-1000A	19
	_FS50-1000A	1

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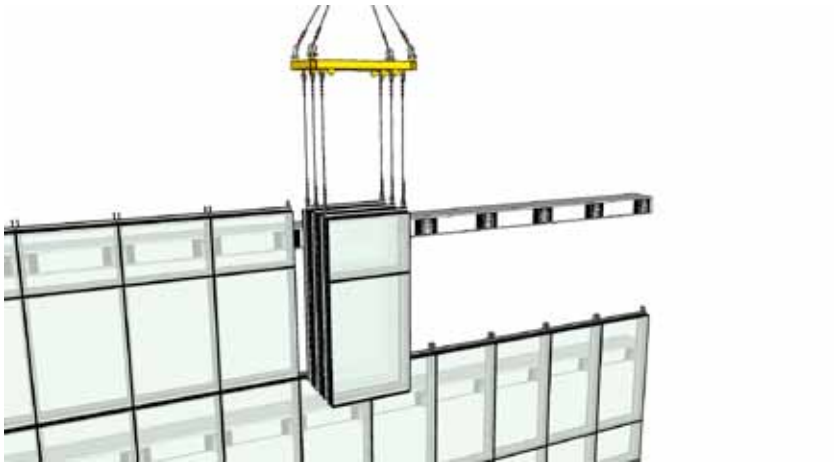
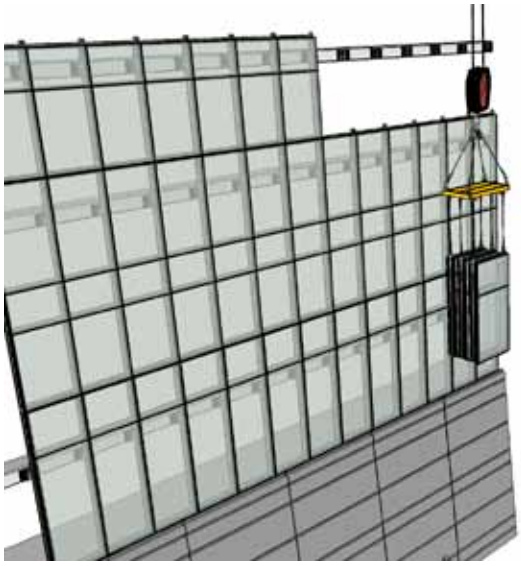
above: Sample ESP output, parts list generated by proprietary Enclos program from 3D building model.

Virtual Construction and Prefabrication



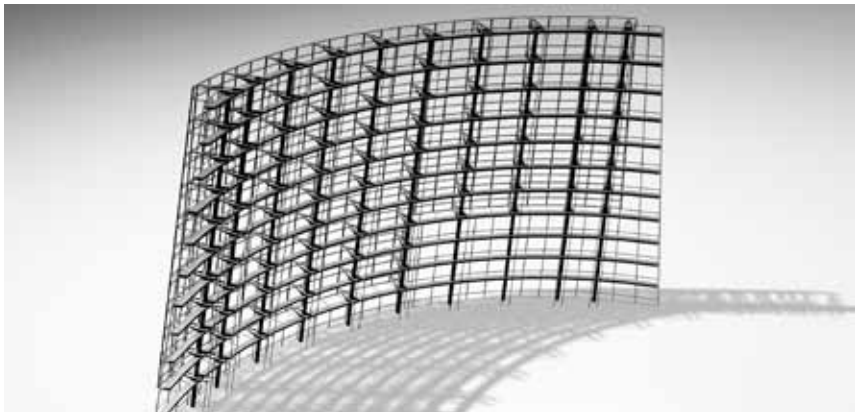
As strong as the Enclos design and engineering capability is, it merely serves our core strength of project management and site operations. Enclos simply dominates when it comes to performance on the building site. In fact, the leading factor in Enclos being selected as the facade contractor is its demonstrable track record of on-site performance. It is in this playing field that the Enclos operations teams have developed methods to save everybody time and money, not just in initial cost, but also in the ongoing problem solving that must occur to assure the ultimate success of a construction project. The team has developed installation strategy to speed erection, and our design team has delivered solutions in support of these strategies. Our site operations teams also work with our fabrication teams to develop just-in-time deliver strategies to ease congestion on the dense urban sites we so often work. Our site operations teams value the BIM as an installation planning tool.

In addition to 4D visualization, Enclos uses BIM tools to plan and simulate assembly and installation activities. An example is the validation of the design and operation of the triple-pick lifting device for the NGA project. Enclos was able to demonstrate the safety of its proposed method statement to the general contractor by presenting a virtual animation of the installation process. Another example is the bid proposal for the Jacob Javits Conference Center, where the building was modeled in its entirety to plan crane type and placement, and to show the sequence of demolition and re-cladding that would allow for continuous operation of the building during construction. Yet another example is the LA live project where, during design development, operable windows were modeled and color-coded to clarify design intent to the fabricator. Window operation was also simulated. On the same project, complex curtainwall unit stepped stack details were modeled to explain assembly sequence and sealant requirements. Using the power of BIM, Enclos is able to improve safety, reduce errors, shorten build schedules, and increase overall productivity.



top and right: Images from a simulation demonstrating a proposed time-saving installation technique to an interested owner and general contractor.

Software Tools



Primavera P3

Primavera Project Planner is the recognized standard for high-performance project management software. It is the most used program in the construction industry for scheduling and project activity tracking. Primavera was purchased in 2008 by Oracle, a leading provider of project portfolio management (PPM) solutions. Oracle plans to integrate Primavera with Oracle applications and infrastructure software to create the first enterprise level PPM, helping project-based companies manage the full range of operations with real-time data. At minimum, this assures the future usefulness of Primavera and promises ongoing development that will allow increasing integration with BIM process.

Flovent

Flovent is a computational fluid dynamics (CFD) software package with special capabilities for modeling the complex fluid flow behavior associated with the design of buildings. From predicting the external interactions of wind and thermal energy with the building envelope to modeling the internal flow distribution networks of heating ventilation and cooling (HVAC) systems, Flovent provides all in a single integrated package. The fluid velocity field and spatial distributions of convected properties are solved for by finite volume method discretization of the governing partial differential equations of fluid mechanics, heat transfer, and mass transfer with a multigrid residual-based solver. At Enclos, this software is used to study such relevant phenomenon as transient and steady fluid flow through and around building fixtures, forced thermal convection, and buoyant natural convection in curtainwall systems.

THERM/WINDOW

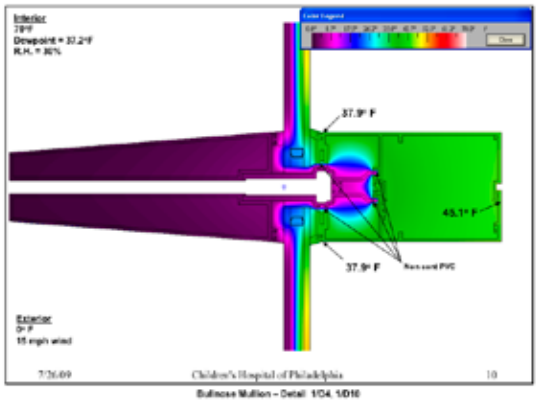
The software programs THERM and WINDOW resulted from a collaboration between Lawrence Berkley National Laboratory (LBNL) and the National Fenestration Ratings Council (NFRC) to create tools for the improvement of the thermal performance of fenestration products. Solutions are developed in accordance with the standard ISO15099-2003 that provides a procedure for assessing the thermal transmittance and condensation performance of fenestration products by finite element method simulations of steady state heat conduction. Additional capabilities approximate thermal interactions resulting from radiation heat transfer and convective currents in frame cavities. At Enclos, these products allow for the determination of overall thermal conductance of curtainwall systems (U-value rating) and condensation resistance factor (CRF).

Navisworks

The Autodesk Navisworks software unites 3D design models from other design tools in multiple formats that can be reviewed and analyzed as a single 3D project. Navisworks combines clash with 4D project schedules and 3D rendering, allowing construction simulation and improving design decisions and project planning.

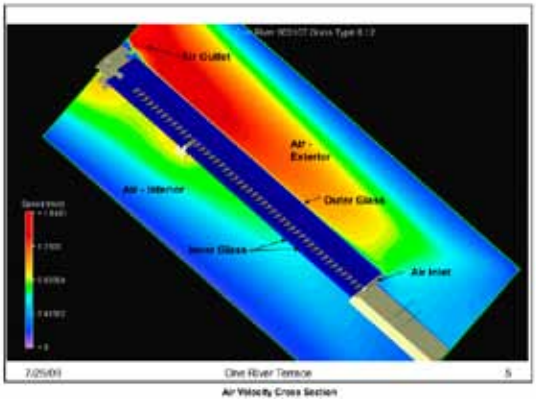
ESP

Enclos has an in-house staff of programmers who develop custom applications designed to extract and process data from design software such as



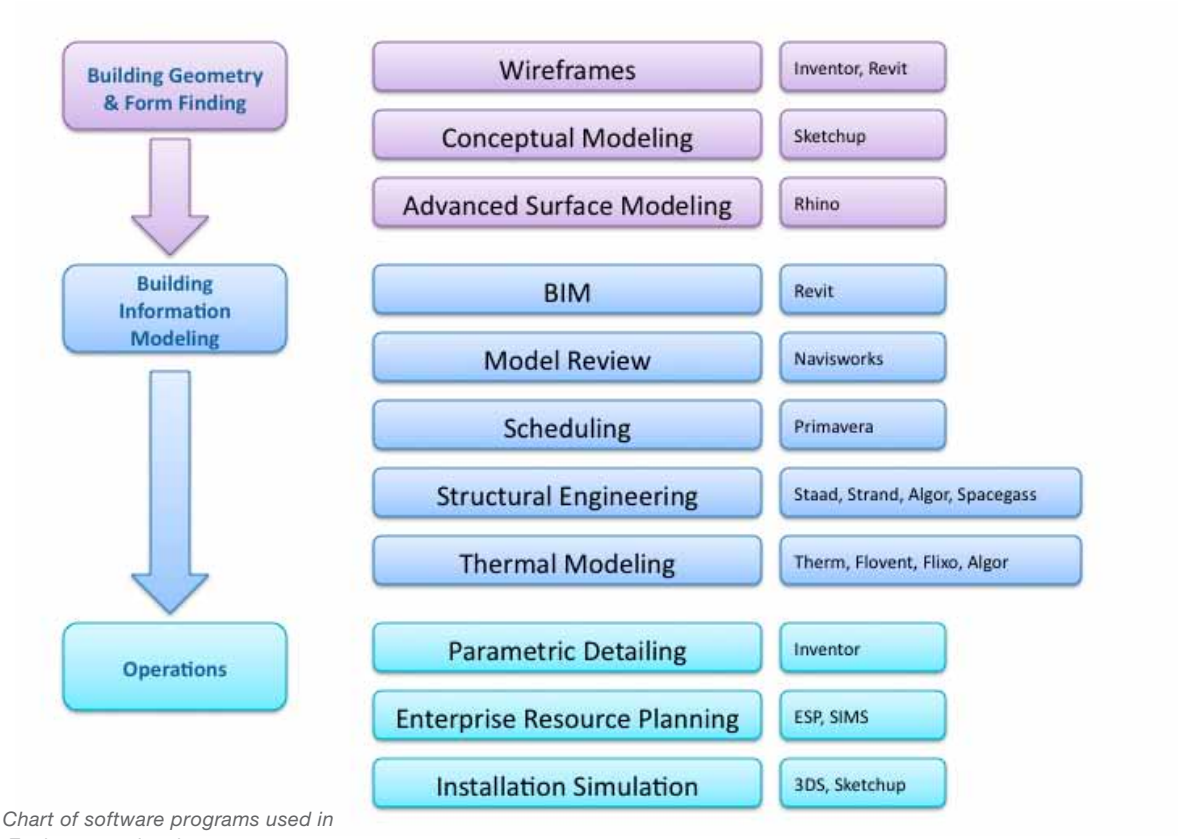
above: 3D AutoCAD model of a custom long-span glass facade for the entry lobby of a convention hall.

left: Image from thermal analysis of custom curtainwall system; detail at bullnose.

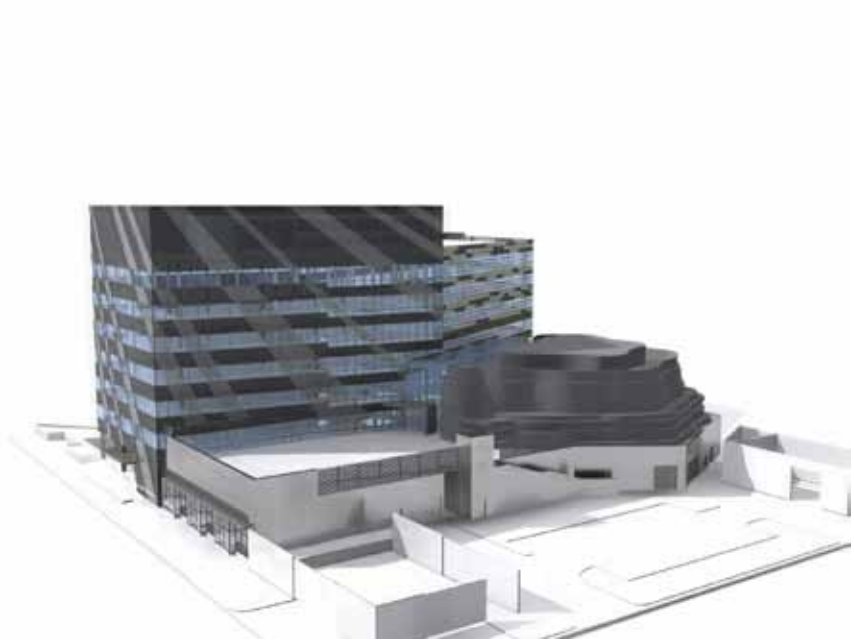


left: Image from CFD analysis on double-skin window system with operable cavity blind.

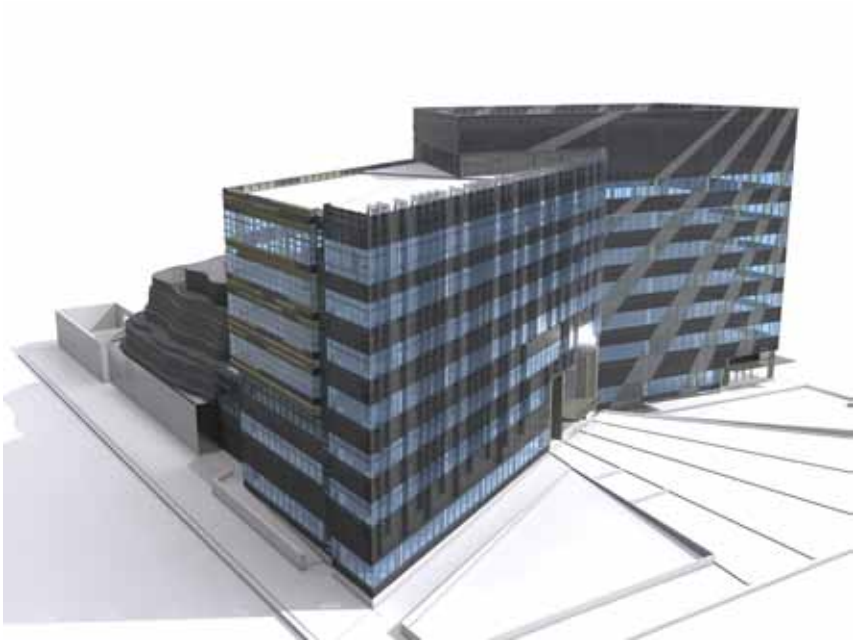
AutoCAD and Inventor. ESP generates nomenclatures from project drawing files. Parts, sub-assemblies, and unit assemblies are associated to releases and floors by detailers, according to the project installation sequence. This information is then processed by the production-planning department of the fabrication facility. Fabrication is released according to the project schedule, matching planned installation closely and using lean manufacturing principles. Materials requirements are verified and orders are adjusted based on the ESP database. This data is also processed by our SIMS application used by the assembly facilities. Parts requirements, shipments received, and inspection records are matched to installation schedule requirements to produce daily assembly plans and expedite missing and non-conforming components. Assembly quality records, shipments to site, and records of installation complete the SIMS information. Software and database structure enable a process following Enclos best-practice management principles where field installation pulls products from other resources. These processes are ingrained in Enclos culture and transfer naturally to the BIM environment, where fabrication, assembly and installation progress (4D) can be documented in the model along with quality records.



above: Chart of software programs used in various Enclos operational processes.



Summary



3D, 4D, 5D and BIM are related processes. BIM, however, is not merely a 3D model, a software program, or an isolated process; it is rather a broad, integrative process that is bringing fundamental change to the AEC industry. Enclos has been busy defining the meaning of BIM as it applies to the building skin. We have made significant progress in developing an internal BIM process increasingly integrated with our best-practice management systems. These internal collaborative processes easily lend themselves to an equally robust collaboration with our extended client base. Developers, architects and general contractors are showing increased interest in engaging the BIM process at the very earliest stages of a building project, and the role that Enclos can play in that process. After all, the building skin effects both the performance and appearance of a building like no other building system, and the building skin is the domain of Enclos Corp.

left: BIM-compatible model originally created in Rhino as part of a project pre-bid analysis. Facade elements can be applied to Revit or other BIM model.

Comcast Center Philadelphia

owner Liberty Property Trust

architect Robert A.M. Stern Architects / Kendall/Heaton Associates

engineer Thornton Tomasetti

gc LF Driscoll Co.

facade consultant Curtainwall Design Consulting

completion 2008

program 57-story, 1,001 ft

building type office

facade design/build services for 698,000 sqft custom unitized curtainwall and 100 ft screen wall

glass IGU's with low-iron and low-e coated glass

key vendors Viracon (Tower Glass), JE Berkowitz (Starphire Glass), Keymark (Metal & Paint), United Skys (Skylight), Firesafing (ICI), Gutherie Glass (Doors, Entrances & Canopies)

description this green building program is draped in transparent glass with 15 to 17 ft between floor slabs; 120 ft high glass enclosed winter garden and atria; dual skin system with integrated and automated shading

Mixing modernism with minimalism on the tallest building in Pennsylvania, Robert A.M. Stern Architects have placed their mark on the Philly skyline with another vertical eye-climb. The 1001 foot tall Comcast Center features a subtle geometric design of large glass planes interrupted by terraces and notches in a fully glazed highly transparent facade that floods the interior spaces with diffused natural light.

Comcast Center is one of tallest green buildings in the nation. The project embraces sustainable building design with the goal of achieving a LEED (Leadership in Energy and Environmental Design) rating from the U.S. Green Building Council. The building structure incorporates 15 to 17 foot floor heights that use 13 percent less energy than conventional floors because of the facade's reliance on natural lighting. A high performance low-e coating protects the building from temperature extremes.

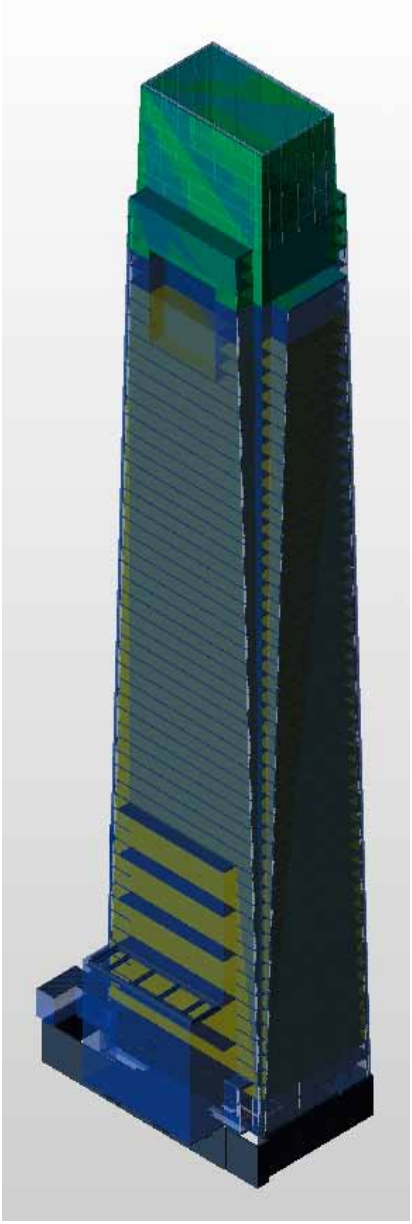
At 57-stories and 1001 feet, the Comcast Center is the tallest building between New York and Chicago.

top: The tower seems to disappear in reflections of its surroundings, featuring an all glass facade and operable windows.

left: View of the building entrance.

A large public winter garden at the base of the tower soars to 120 foot heights and is clad entirely in glass. An advanced facade design features a double skin cavity wall with an integrated sunscreen system to regulate daily and seasonal solar and temperature variations while continuing the structure's theme of maximized day-lighting.

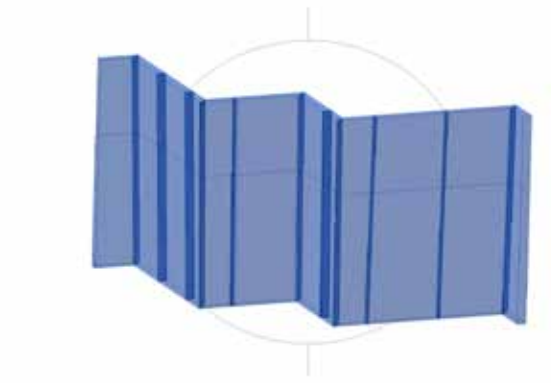
Enclos Corp provided complete design/build services for all facade elements while working closely with the architect during the design phase. Ultra-clear low-iron glass is used throughout the oversized curtainwall units that were fabricated and assembled offsite, then shipped in a carefully coordinated sequence to support the firm's installation crews. Enclos site operations people worked closely with the general contractor to develop an optimum erection strategy for this challenging site amidst its dense urban surroundings.



left: A BIM compatible 3D model of the tower created in Inventor.

below left: 3D model of curtainwall unit.

below: Clear glass encloses the entry lobby.



Station Place Securities & Exchange Commission Washington, D.C.

developer Second Street Holdings LLC, Louis Dreyfus Property Group Inc

architect Kevin Roche John Dinkeloo & Associates

gc Tompkins Builders

completion 2004

program lobby wall: 90 feet high and 60 feet wide; skylight: 55 feet long and 60 feet wide

building type government

structure double curve anticlastic cable net made of 20 mm cables clamped via stainless steel cast nodes. Supported by the perimeter concrete structure and an intermediate steel delta truss

glass face glass—Viracon, 1-1⁄4 inch total thickness, 5'x 5' foot panel size insulating glass consists of 1⁄4" heat-strengthened clear glass with low-e coating on the second surface, a shading coefficient of 0.43, winter U-value of 0.48 and summer U-value of 0.55; 1⁄2 inch air space and silver spacer bar; inner panel consists of 1⁄2 inch laminated glass consisting of 3⁄16 inch clear heat-strengthened glass, 1⁄16 inch polyvinyl butyl and 1⁄4 inch clear heat strengthened glass.

skylight— 15⁄16 inch total thickness consisting of: 1⁄4 inch clear tempered glass with low-e coating on the second surface, a shading coefficient of 0.33, a winter U-value of 0.29 and a summer

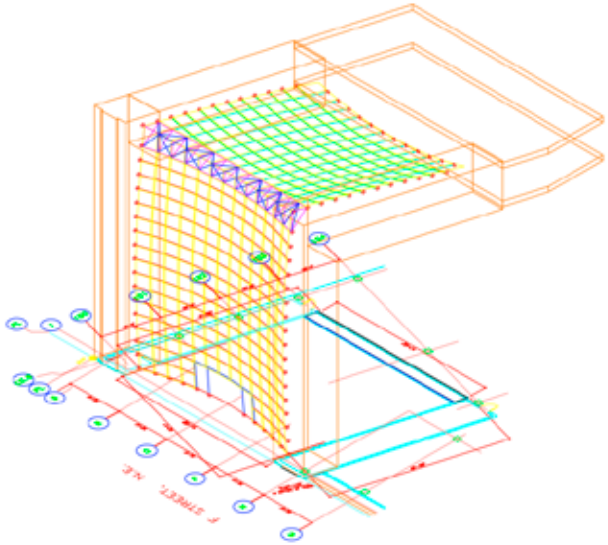
U-value of 0.29; ceramic frit on the second surface, with Viracon Pattern 5005 and frit color V912-LF (white); 1⁄2 inch air space and silver spacer bar; 1⁄2 inch laminated glass consisting of 1⁄4 inch clear tempered glass, 1⁄16 inch PVB and 1⁄4 inch clear tempered glass for the inner panels.

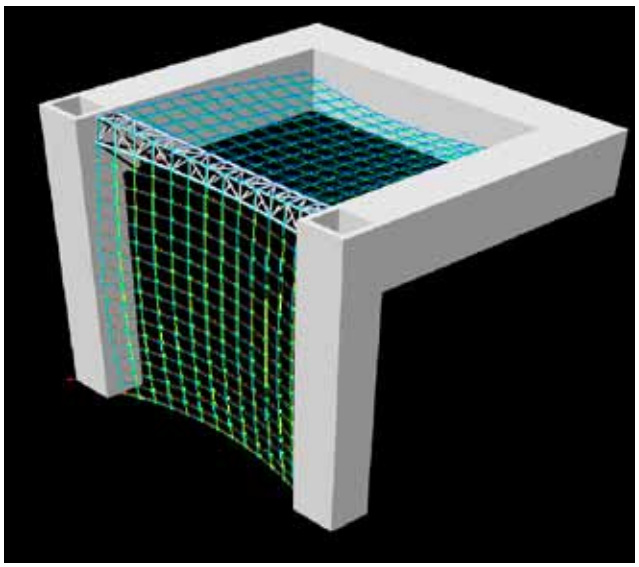
Glass-clad cable-net structures are fast evolving in the United States as one of the dominant forms of high transparency facade technology.

The lobby area of SEC is enclosed with a cable-net supported 60-by-90-foot glass wall and a 60-by-60-foot skylight. The combined surface area is approximately 9,000 square feet. The structure comprises 28-millimeter stainless steel cables and clamp fittings or nodes. A 60-foot-long double curved triangular truss spans the two concrete super columns at the top of the wall and provides support at the intersection of the wall and skylight. The truss also acts as a load transfer and stabilizing element for the adjacent building towers. The wall net comprises 15 rows of horizontal cables and 12 rows of vertical cables and the skylight net comprises 12 longitudinal and 10 transverse cables. The vertical cables of the net wall align with the longitudinal cables of the skylight.

The vertical and horizontal cables are clamped at their intersections with custom stainless steel node assemblies, which in turn receive the hardware by which the glass is fixed to the net. The slight radius the wall structure follows in plan provides the curvature in the horizontal direction. Opposing curvature in the vertical direction is provided by embedded cable connections within the concrete super columns. The opposing curvatures give the cable net its saddle shaped surface and stability.

In practice, cable-net structures are remarkably resilient and forgiving as they are designed to move. They can deform many times the deflection criteria of conventional steel or aluminum structures without permanent deformation or failure. Deflections in the flat nets can equal 2 feet under wind load in a 100 foot span. Contrary to being a problem, this allows them the flexibility to best withstand the extraordinary loadings resulting from seismic events or bomb blasts. As with all emergent building technology, cable nets number among the highest priced facades in the marketplace, due largely to development costs. However, the systems are relatively material-efficient and very simple, and market pricing drops rapidly. In efficiently designed structures, with the dissemination of assembly and installation know-how, look for cable-net technology to become competitive in price, resulting in widespread application.





opposite page: A cable net supported glass wall and skylight roof enclose the entry lobby.

top right: Interior view of the skylight roof.

middle right: View of 3D model.

right: rendered view of 3D model showing boundary building structure.

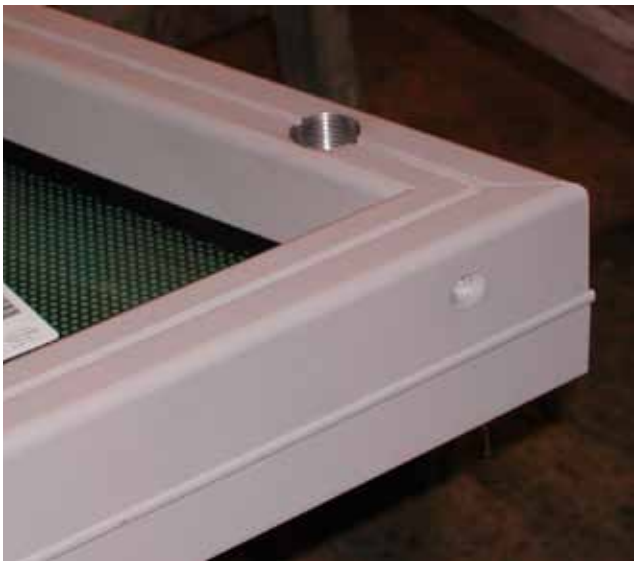
Station Place Securities & Exchange Commission Washington, D.C.

Enclos has developed various glass systems for application on its cable net designs, including point-fixed drilled and non-drilled systems and panelized systems. For the SEC net, Enclos has developed an innovative unitized glass-framing system that can be bolted directly to a modified cable-net node assembly. The system avoids the premium cost associated with point-fixed glass systems and allows for competitive domestic glass supply.

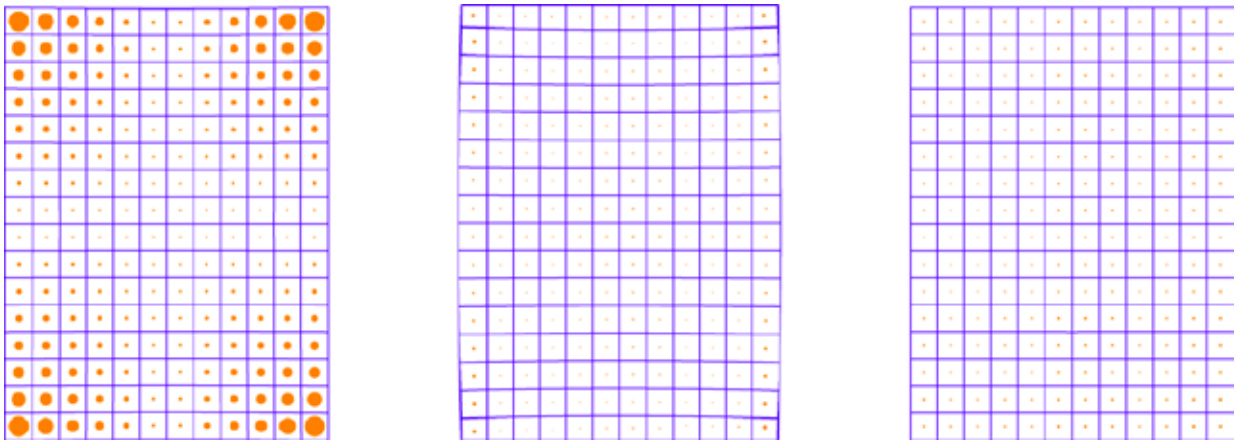
The anticlastic geometry will result in a major mitigation in the deflection of the cable nets. However, this feature results in a warped surface that cannot be easily clad with the planar glass.

Double-curved glass is expensive and impractical for insulated glass and cold bends have limitation on the glass size and the preload warpage.

Node detail



Glazing Frame



Analysis of relative amount of warp in glass panels; left geometry hyperbolic paraboloid; middle geometry hybrid; right geometry torus.

1

2

3

4

In this project Enclos first optimized the cable net geometry to achieve a minimum amount to distortion while maintaining enough curvature to control the skylight and wall deflections.

The result is a hybrid geometry which is extracted from the surface of a torus.

The remaining warp is then concealed in the interstitial space of the thin aluminum frame.

Installation Sequence

In order to achieve the proper shape in the double-curved nets, the clamps must be accurately positioned on the net, and the tensioning of the net must be accomplished with all cables, vertical and horizontal, simultaneously. This requires rigorous methodology frequently involving sophisticated hydraulic jacking gear. Enclos utilizes special survey techniques to map the position of each node. Compensating adjustments in the tensioning of the net can then be computed and implemented. The trick, then, with the cable net structures is in the tension: first, determining appropriate theoretical cable pre-tensions with respect to boundary conditions, so as to yield the most efficient shape of the net. The following Sequence was used at SEC:

1 assemble the net in the factory and attach cables and nodes in the horizontal position allowing compensation for final tensioning

2 pretention the net using perimeter hydraulic jacks attached to a temporary space frame with similar stiffness as the actual structure

3 adjust the nodes to their final position using accurate laser measurements and clamp the node with the required torque values

4 wrap the cables and nodes in plastic covering and de-tension the net and roll the net around a spool

5 transport the spool to the site

6 erect the supporting structure including the delta truss and assemble the perimeter jacking system at the support locations

7 drape the net and attach to the perimeter jacking system and the delta truss

8 tension the net to the final position utilizing all of the jacks simultaneously and check node locations; install glass

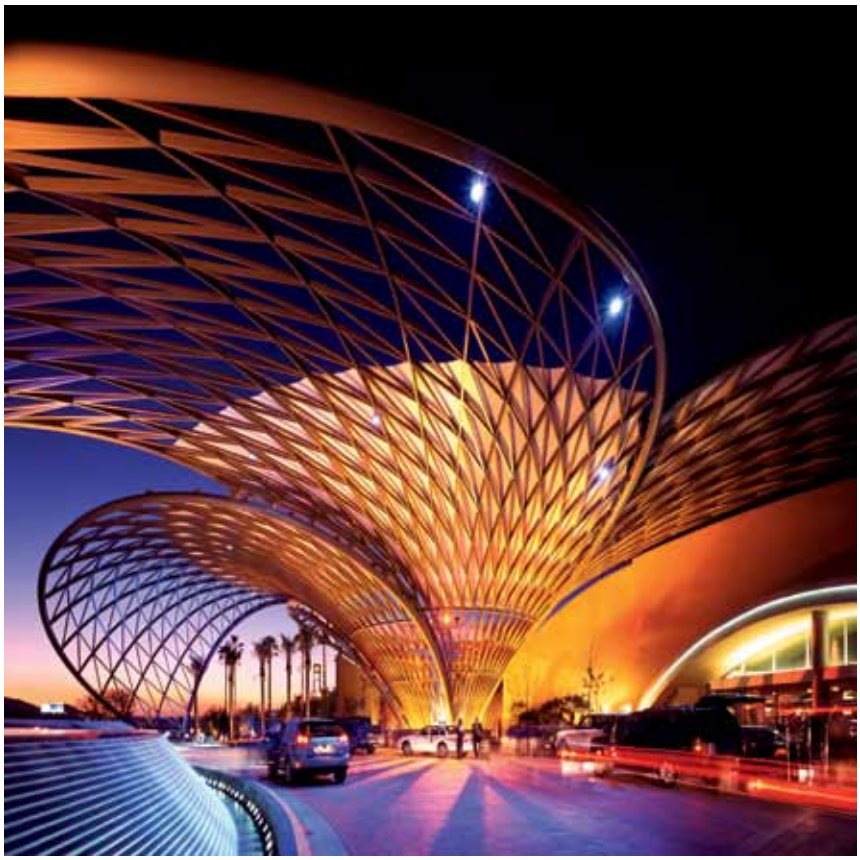
5

6

7

8

Desert Bloom
Porte Cochere
Casino Morongo
Cabazon, CA



owner Morongo Band of Mission Indians

architect The Jerde Partnership

engineer ASI Advanced Structures

gc Perini Building Company

completion 2004

program design/build of 27,000 sqft custom steel fabricated to AESS standards (Architecturally Exposed Structural Steel)

building type hotel / casino

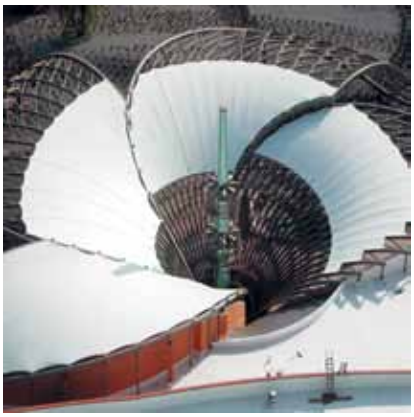
description this dramatic steel structure is intended to mimic a desert flower, with petals rising 40 feet over a 120 foot span

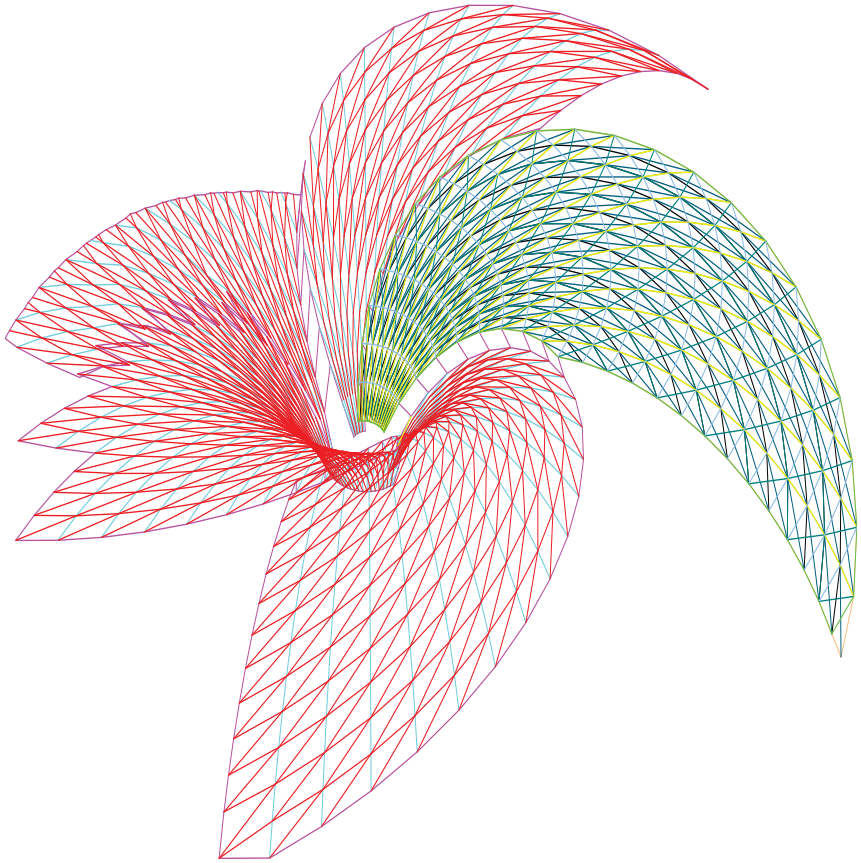
Desert Bloom won the prestigious National Engineering Award of Excellence from the American Institute of Steel Construction, 2004.

Architecturally Exposed Structural Steel (AESS) is the standard published by the American Institute of Steel Construction intended to account for the unique requirements of steel fabrications in exposed applications where visual quality and craftsmanship are paramount considerations. The increasing use of highly transparent facades, especially in long-span applications of 25 feet and greater, have significantly expanded the use of exposed steel structures of all types, including truss and cable systems. Conventional welding and steel codes provide little guidance with respect to, for example, the visual quality of a weld. The designer may request a ground and polished weld, or a particular surface quality to a steel component. The AESS specification is intended to address these types of issues.

Enclos has provided AESS services to its clients for years, involving custom canopy and lobby structures of exposed steel. Recognizing the growing importance and increasing sophistication of this service, the firm took steps to enhance its capabilities by acquiring strategic assets from a company expert in the field of AESS. With certain proprietary technology and the core ASI staff now part of the Enclos team, the company is able to provide comprehensive design/build AESS services on any project regardless of size or complexity, including the most advanced, long-span structural glass facade systems.

The Dessert Bloom is a tour de force of steel structure design fabricated under an AESS program. To facilitate erection, each of the four petals was divided into a series of individual curved wedge shape segments (“ladder” frames). The division of each of the petals into lightweight ladders made the process of fabrication, shipping, and installation relatively simple and straightforward. The ladders were bolted together in the field with galvanized steel bolts. The central light tower stands 60 feet tall. It was fabricated in two sections that were bolted together in the field. Approximately 350,000 pounds of custom-fabricated steel and more than 5,000 bolts were used for the project.





opposite page: The lattice grid structure defines the entry to the casino and hotel.

top: An evening view from the nearby freeway.

above middle: Construction shot.

above: Construction shot showing fabric membrane in place.

right: View of 3D model.

Donna Madsen

BIM Coordinator

In her role as BIM Coordinator, Donna is responsible for coordinating project-related BIM for Enclos, including the training of BIM technicians. Her past work includes extensive involvement with Revit Building and AutoCAD, both as a designer, technician and trainer. She has worked as a project manager and BIM coordinator with an emphasis in facility space planning. Donna has experience at specification writing and the development of CAD and BIM standards. She has developed hundreds of Revit families, and worked as part of a Revit help desk team. She is an excellent communicator and experienced in the clear and concise communication that must take place between the constituents in BIM process.

Larry Schluter, MSCE

Director of Information Technology

Bachelor of Technology – University of Northern Iowa, 1982

Master of Science in Computer Engineering – University of New Mexico, 1992

Larry has been working with Enclos Corp since 1996, developing customized tools to automate and improve process workflow. He has been the Director of Information Technology since 2005, overseeing ongoing technology improvements within and across Enclos operations management systems.

Larry, also a member of the BIM Implementation Committee, has been instrumental in moving Enclos Corp towards a full implementation of BIM. His work has involved developing processes and tools that seamlessly integrated the flow of information from engineering operations to the fabrication plant. Currently he is focused on facilitating the flow of information to site operations by developing tools that will provide simplified, real-time access to mission-critical information. He is also developing optimized input systems for site progress information that can be used not only by Enclos personnel but also by our clients as an aid in maintaining the building throughout its lifecycle.

Michel Michno, MSME, LEED AP

Vice President

Master of Mechanical Engineering – Ecole Nationale Superieure d' Arts et Metiers Paris, 1984

Michel is the Vice President of Enclos responsible for design and engineering operations company wide, including one of the most aggressive research and development programs in the construction industry. With over two decades in the facade industry specializing in the design, engineering and fabrication of high-end custom curtainwall technology, Michel is a seasoned designer, manager and leader. Michel joined Enclos in 1998, and was with related enterprises as far back as 1988.

With a particular focus on design and engineering operations, Michel is a key player in the Enclos BIM initiative. He shares a personal commitment with other top executives that comprise the company's BIM Implementation Committee (BIMIC) to the establishment and ongoing development of integrated BIM processes throughout Enclos operations centers. He is especially focused on integrating the various software platforms used by the company into an integrated design and engineering process with BIM as the unifying element. He is also deeply occupied with the ongoing evolution of the company's collaborative interface with the often-disparate BIM technology and processes of our diverse client groups.

Enclos Press Publications

Inter-Story Acoustical Evaluation of Unitized Curtainwall Systems - 2008

Analysis and Design of Spandrel and Shadowbox Panels in Unitized Curtain Walls - 2009

Enclos: Collective Works - 2009

Facade TecNotes Series:

1 *Skylight*

2 *Double Skin*

3 *Architecturally Exposed Structural Steel (AESS)*

4 *Airports*

5 *Healthcare*

6 *BIM and the Building Facade*

7 *Cable Nets*

8 *Security*

9 *LEED Skins*

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