Get on the Fast Track in Structural Design

The Evolution of an Automated Engineering Process

By Dale E. Brasuell, P.E., S.E.

When a large multi-national corporation found themselves with design and budget problems on a large industrial project, Burrough — Brasuell Corporation was contacted because of their unique approach to structural engineering projects. Burrough - Brasuell Corporation (BBC) is a structural engineering firm that specializes in forensic engineering and large industrial commercial facility design.

Structural engineers have many software choices, but the key to efficiency and speed is that project information is only entered into the computer once. This article explains how BBC has integrated such software throughout the structural design process. This approach centers on a systematic procedure for the use of structural engineering computer programs, such as SAP2000, STAAD.Pro, GT STRUDL, RISA 3D, and many others. These programs are well known individually, but what distinguishes the procedure used by BBC is the use of an interface program and the CIS/2 interface developed by A.I.S.C. The interface program, Structural Desktop, ties these applications together running inside AutoCAD or Architectural Desktop.

The design of the industrial facility mentioned above will be used to illustrate this integrated process. In this design, the interface software was used to translate information from AutoCAD to analytical packages. The information was imported back to AutoCAD for creation of contract documents. To collaborate with other engineering disciplines, AutoCAD and Architectural Desktop were used. The CIS/2 interface provided translation from analytical files to steel detailing software.

Many engineers are unaware of just how effective sharing files between software can be with the software that they have in their offices today. The desired goal is a seamless flow of information between all software packages and human users involved in a structural project. Often this goal can be approached by examining the options that are available in the software that the engineer is using.

Putting the Procedure to Use

This project was a Design-Build industrial facility and consisted of a steel superstructure and a cast-in-place grade beam and drilled-pier concrete foundation. The interior structure was dictated by process considerations, and was a complex and non-repetitive layout with no similarities between any two bays or levels. In addition, the facility was to be erected next to an existing facility and space for erection and storage was at a premium. Finally, the process equipment had to be installed into the structure as an integral part of the erection process.

The workflow for a typical project of this type is:

- Initial concept drawings and preliminary process design
- Preliminary structural design
- Interactive collaboration with other disciplines
- Budget & Scheduling
- Final structural design
- Develop structural design drawings and foundation drawings
- Submission to the contractor for permitting and purchasing
- Submission to fabricator to create shop drawings
- Shop drawing review
- Fabrication
- Erection

Originally, this project was designed and bid using conventional procedures. The process took over a year, and resulted in a bid that was twice the budget and would not meet the required deadline for completion. The projected steel order was approximately 1,200 tons of steel and the project could not be completed within the eight months allotted. BBC was engaged to examine the contract documents and to determine if the structure could be redesigned to fulfill the design requirements, fit within the budget, and meet the required deadline for completion.

After the review, Nabholtz Construction of Conway, Arkansas was engaged as the contractor and with Burrough – Brasuell Corporation undertook to provide a Design-Build proposal.

Beginning in May of 2004, Dale Brasuell of BBC began preliminary design by creating a 3D model of the proposed structure, drawing lines and 3D faces in AutoCAD and assigning member or plate element properties to them through the Interface program. The interface model was exported directly to an analytical program for three dimensional analysis. A full analysis of the entire structure in 3D permitted the structure to be redesigned with only 700 tons of structural steel, but with the process layout unchanged and the same volume for the building. Importing the modified analytical file back into the interface software provided the Contractor with a complete Bill of Materials for steel and concrete for pricing purposes. This resulted in the award of a contract for the design and construction of the project on the first of June, 2004.

The next step was evaluation of the process layout with the client to create a more efficient structure. As the process layout was revised, the new structure began to take shape as a 3D line model in AutoCAD. A new interface model was created directly from the AutoCAD line model during the second week in June. Three different analytical tools were employed to perform cross-checking of the analysis. These were STAAD.Pro, GT STRUDL, and RISA 3D. All analytical files were created through

The Software

- AutoCAD
  Autodesk, Inc.
- Structural Desktop
  Structural Desktop, Inc.
- Architectural Desktop
  Autodesk, Inc.
- STAAD.Pro
  Research Engineers, Inc.
- GT STRUDL
  C.A.S.E. Center, Georgia Tech
- RISA 3D
  RISA Technologies
- Tekla Structures
  Tekla Corporation

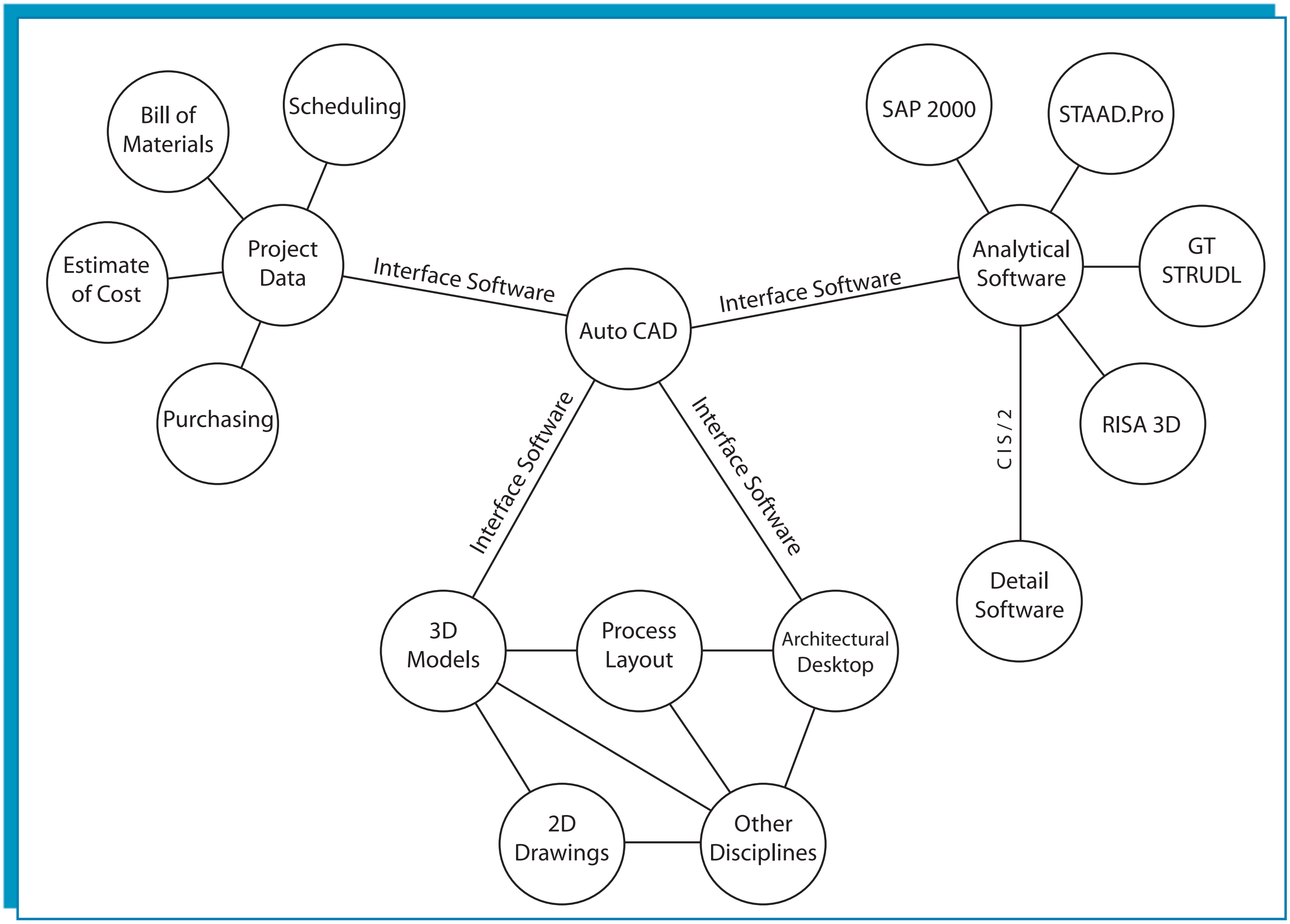

Figure 1

interface software from the same 3D model. The model included all concrete grade beams and piers, so that the foundation could be designed and checked in the overall analysis. These analytical efforts permitted reduction of the required steel to 500 tons with improved functionality.

While the engineer was refining the structure, an engineering intern was creating 3D models of the equipment for the process layout, and 2D layout drawings. These models were created using a combination of AutoCAD solids and Architectural Desktop massing elements.

A final, approved analytical model was reimported into AutoCAD. The members were adjusted using the interface software to their true length, and a final detailed Bill of Materials was created. The structural steel mill purchase order was placed in the third week of June, 2004, three weeks after the contract was awarded.

AutoCAD drawings consisting of plans, elevations, and a 3D model were sent at this time to the other engineering disciplines for their use. The 2D equipment layouts created by the engineering intern during the creation of the 3D models were incorporated into the drawings so that all services and facility requirements could be designed.

The next step was the creation of an Architectural Desktop model automatically from the Structural Desktop 3D model. The structural elements in Architectural Desktop were checked against the process layout 3D model for interference and collisions, and the process layout was finalized.

While the engineering intern was working with the process layout, the engineer was running the analysis of baseplates and designing typical connection details. Connection details for joist girders, beams, and bracing were thus ready to provide for the steel detailer so that his software could detail all connections.

During this same period of time, the designer was using the interface program to extract drawings of the foundation plan, plans and details for the purpose of creating a foundation permit application. All of this information was available from the final adjusted analytical model. Approximately 95% of the required 2D drawings for the foundation were created automatically from the interface model.

Next, using the final analytical model, a GT STRUDL file was created that included the physical members (reflecting the true lengths of the members) and member eccentricities, or offsets. The CIS/2 file that was created from this data represented each member in the building model in its proper position and orientation. This complete model file was e-mailed to MBM Steel Fabricators of Russellville, Arkansas. The CIS/2 file was imported directly into Tekla Structures for steel detailing. This file was sent the second week in July, 2004, six weeks after the contract was awarded.

At this time, the handrails, stair towers, wall girts, door frames, and all other miscellaneous steel items were designed and added to a an analytical file based on the final analysis file for the structure. Exporting this file to a CIS/2 format permitted the steel detailer to have a complete and accurate basis for all detailing of all steel in the structure. The CIS/2 file for stairs and miscellaneous steel detailing was sent by the end of July, 2004.

When the structural steel CIS/2 file was completed and sent to the steel detailer, the model was complete for extraction of all the 2D drawings for plans and elevations required for structural steel in the building permit process. The architect had also worked with the models and drawings provided and had completed his work as well. The project had proceeded so rapidly that the only areas prepared to proceed to the permit stage were the structural and the architectural. The contractor took the unusual step of applying for a permit solely for the erection of the structural steel in order to maintain the project schedule.

The final building permit was applied for on August 17, 2004 when the electrical, mechanical and civil work was completed. This did not detract from the schedule, since so much of the process and structural work had to be completed before the other disciplines' work could begin. The building was completed on schedule, and the process equipment was ready for testing in January, 2005, on time and under budget.

How was it different?

The workflow for this project was:

- Concept development from initial Contract Documents
- Structural design, process design, and collaboration
- Final 3D Model adjusted in Structural Desktop
- 3D Model and drawings provided to other disciplines
- Contract Documents extracted from model for permitting and purchasing
- Submission of CIS/2 file to fabricator to create shop drawings
- Fabrication
- Erection

The concept for this project would have been derived from the initial efforts by others regardless of what procedures were used. However, the project differs sharply from that point, beginning with the evolution of a structural design and process design with inclusion of other disciplines in the earliest design stages. The collaborative process at that level made it possible to create a final 3D model, correctly representing the design, in a very short period of time. The flow between software packages is displayed in *Figure 1*.

Once the final 3D model was created, the ability to direct the information to other analytical packages, directly to 2D drawings through automated processes, and to 2D and 3D drawings that could be shared with the other disciplines cut several steps of interaction and information-sharing from the process. The 3D model provided a Bill of Materials, all the necessary drawings for permitting and purchasing, and a data file that could be run directly through the steel detailing software. One example of an advantage derived is that the steel detailing estimate was 1,440 man-hours but the actual work required, by virtue of the direct connection between the analytical and detailing software, was 80 man-hours, a ratio of 18 to 1.

The savings in the steel detailing translated directly into an immediate start for fabrication, and brought the fabrication end-date within the required schedule. This allowed steel to be delivered and erection to begin as soon as the foundation was completed. Sections of the building were detailed and fabricated in sequence to take the maximum advantage of the space available and coordinated with the delivery and the installation of the process equipment as needed for installation.

Conclusion

This project was completed on time and within budget because steps were merged together so that the benefits could be compounded throughout the project cycle. In new generations of engineering software, the seamless flow of information, both numerical and graphical, will become even more transparent to the user. Just as the development of computers has created a generation of engineers who are strangers to the sliderule, so new generations of software will free the engineer to practice more art in the science of his engineering.

The impact of 3D graphics and analysis cannot be ignored in the evaluation of this procedure. Because the model created for this project was complete, with all primary and secondary steel, a more accurate analysis was performed and complete drawings and bills of materials were extracted from that model. This process does not guarantee that the design is correct or complete, but it provides an absolute assurance that all parts of the building will fit together in a consistent manner.

The evolution of an automated engineering process is far from complete. BBC has looked for steps where information has been transcribed from one design process to another manually, and attempted to bridge these gaps through merging these processes. The software that was used for this project is not being recommended over any other. There exist many CAD packages, many analytical engines, and many steel detailing packages that include differing levels of compatibility with each other. What is being suggested is that engineers should evaluate their software in the light of the options available. When automated translations are used between software packages, there are increases in efficiency and improvements in accuracy.▪

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