

PENN STATE BALLPARK

University Park, Pennsylvania



Streamlining the Structural Steel Design and Construction through Computer Modeling

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CONSTRUCTION DEPTH RESEARCH

STREAMLINING THE SUPERSTRUCTURE DESIGN & CONSTRUCTION THROUGH COMPUTER MODELING

1. Chapter 1: Introduction

- a. In July 2005, the General Services Administration (GSA) announced that all new projects requiring their funding will need to include a building information model (BIM) as part of the project proposal.
 - i. The term BIM is a relatively new term in the industry, but in the past has been noted as a project model or multi-dimensional (MD) modeling.
 - ii. Essentially a building information model is a materialized 3D model meaning that everything in the building is drawn with its true properties. An example of this is with an exterior masonry wall. A typical 3D model would just draw the dimensions of the wall, whereas a BIM details the wall with its brick façade, air barrier, sheathing, studs, etc. for the wall properties.
 - iii. The GSA's requirement with a BIM needed for all of their future projects is a new approach to project design and delivery. In the past, many projects have been designed in three dimensions, but have not included the object properties which would make it a BIM.
 - iv. Computer aided project development has been in the industry for quite some time, however implementing it has been a hardship. Many owners, architects, and construction managers have not seen the value that these models can bring to a project mostly due to initial costs and time to develop the models.
- b. On-going Construction Industry Problems:
 - i. Duplication during the steel sequence continues to be a problem in the industry. The structural engineer designs the steel structure for the building and then the structural steel contractor, upon award, re-designs the building through steel shop drawings. Because of the need to produce these shop drawings, steel cannot begin fabrication until six to eight weeks after an award is made to the steel contractor and shop drawings are approved.
- c. This research proposal will focus on a BIM of the superstructure for *Penn State Ballpark*. The goals and objectives of this research are to answer the following questions:
 - i. Can the construction industry reduce the waste in the steel shop drawing process through implementing building information modeling?
- d. By analyzing existing practices (shop drawings and coordination) during the steel phase of a project, I will propose a more streamline process for the steel phase of a project.

2. Chapter 2: Background/Literature Review

- a. Currently, there has been a lot of research devoted to computer aided design/construction research. Most of this research is based on project case



- studies and not how to effectively implement computer aided models on a construction project.
- b. Most projects are documented with a 3D model which is made during the preconstruction phase of a project. These models are used to develop a rendering of the project which is mainly used for marketing purposes. Unfortunately, these models are 3D models and not building information models. Furthermore, these models are very rarely taken from the design phase of a project and implemented in the construction phase.
 - c. During the summer of 2005, I began my initial study of building information modeling. My research paper was titled, “Integrating Building Models In the Construction Workplace,” and documented some of the current practices with computer modeling within the industry.
 - i. The most valuable information received during the research timeline were the responses to a series of survey’s I sent to architects/engineers, owner representatives, and construction managers. The survey’s asked a series of questions relating to implementing a 3D and 4D model on the project and the value that each can bring to a project.
 - d. Many industry members are interested in implementing new technology on a project, but either do not know how or cannot afford the cost and time associated with developing a model. Some trades in the industry already implement 3D models to assist with pre-fabrication of systems with the steel trade being at the top of the list in terms of implementing technology.

3. Chapter 3: Objectives and Methods

- a. Problem Statement
 - i. Duplication of structural design delays fabrication of structural members and is a problem that affects each project in the construction industry.
- b. Specific Measurable Objectives
 - i. Review literature and understand current practice.
 - ii. Develop a solution to implement a Structural BIM on a project.
 - iii. Test and validate proposed solution.
 - iv. Leave ideas for future research.
- c. Methods
 - i. First, I will read articles documenting projects that have implemented building information modeling and understand how the research was performed.
 - ii. Next, I will find any articles relating to the shop drawing sequence of a project in order to see if there is already documented waste in this process.
 - iii. Then I will find any articles relating to the steel fabrication of a project and any known documented problems that may exist.
 - iv. Through building information modeling during the design phase, the time invested during the shop drawing phase can be decreased and coordination between steel material fabricators can be more easily achieved.



- (1) I will make a building information model of the superstructure sequence of the project using Autodesk Revit Structure 2. This program has all of the structural members and shapes that are in the current steel manual including joists and decking which will allow me to produce an accurate model.
- v. I will then obtain a copy of the CIS/2 modeling standards which describe means of information transferred between steel computer software.
- vi. Once the computer model is made, I will contact steel industry organizations, structural engineers, steel contractors, steel detailers, and construction managers and discuss with them the items that are needed to go from design to fabrication.
- vii. By documenting the problems found in the shop drawing process, I can propose an alternative means and methods to the structural design and approval phase of a project.
- viii. Lastly, I will describe the overall affect of implementing a BIM for the structural sequence through a case study project and document the value of such a model for fabrication and design coordination.
- d. Expected results / outcome / benefits
 - i. In developing a BIM of the superstructure for *Penn State Ballpark*, I will be able to address better techniques in going from steel design to fabrication stage of a project. Furthermore, I will be able to address better coordination techniques between steel suppliers.
 - ii. This research project will help me identify current problems and time constraints associated with the steel/structure phase of a project and allow me to suggest alternative methods to beginning the construction of a steel structure.
 - iii. Because the steel phase of a project is often on the critical path, any time that might be able to be saved could result in a quicker delivery of the entire project. This research will benefit structural designers, construction managers, and steel fabricators as well as leave ideas for continued research in streamlining the design to construction of the structural sequence.
- e. Timeline
 - i. January 2006
 - (1) Read articles about current BIM projects, studies performed with the steel sequence, and any articles with current fabrication practices.
 - (2) Develop a BIM of *Penn State Ballpark's* superstructure.
 - ii. February 2006
 - (1) Contact steel contractors and discuss questions proposed above.
 - (2) Analyze the results of the study.
 - iii. March 2006
 - (1) Summarize and document results of study.
 - iv. April 2006
 - (1) Present results of study to construction industry members.



3.0 STREAMLINING THE STRUCTURAL STEEL DESIGN & CONSTRUCTION THROUGH COMPUTER MODELING

3.0.1 EXECUTIVE SUMMARY

A familiar problem in the construction industry is that a building is often designed on paper during the design phase; and then re-designed to determine “ability for construction” during the construction phase. The idea of re-design is very apparent with the steel, mechanical, electrical, and plumbing trades with the requirement of shop drawing completion on many projects for those trades.

The following discussion focuses on streamlining the structural steel design to construction through the implementation of computer modeling, along with how to take advantage of current technology to help a project team is also addressed.

In order to propose a more streamline process for the steel phase of a project through computer modeling, a current understanding of steel design and construction practice must be analyzed. The research methods included journal and industry article reviews, telephone interviews with steel industry professionals, and the development of a steel BIM for *Penn State Ballpark*.

Interviewing industry professionals proved to be a very valuable method to fully understanding the steel design to construction process. Each industry professional was very helpful and insightful with responding and adding to the proposed interview questions.

A case study with the *Penn State Ballpark* project examined the effects a BIM could have on a better delivery on the design and expediting the steel shop drawing duration with a building information model supplied by the structural engineer. The implementation of such a model benefits each project team member from design to construction.

Construction industry trends will show more and more projects implementing this technology over the next few years. The CIS/2 modeling standards will help software developers implement the proper exporting capabilities to make different software packages interoperable with each other.

By analyzing existing practices during the steel phase of a project, a more streamline process for the steel phase of a project through computer modeling has been addressed. The above research discussion has benefited structural designers, construction managers, and steel fabrication because each entity can more effectively perform his/her job with the implementation.



3.0.2 CHAPTER 1

Problem Statement

A familiar problem in the construction industry is that a building is often designed on paper during the design phase; and then re-designed to determine “ability for construction” during the construction phase. The idea of re-design is very apparent with the steel, mechanical, electrical, and plumbing trades with the requirement of shop drawing completion on many projects for those trades.

Duplication of design during the steel phase of a project often presents challenges to the project team. “[The] development and approval of drawings is a tedious but important component of the fabrication process that enables the project to be properly fabricated and assembled smoothly during the erection process” (Danso-Amoako et.al). The structural engineer designs the steel structure for the building and then the structural steel contractor, upon award, re-designs the building through steel shop drawings. Because of the need to produce these shop drawings, steel cannot begin fabrication until six to eight weeks after an award is made to the steel contractor and shop drawings are approved. Consequently, duplication of structural design delays fabrication of structural members and is a problem that affects each project in the construction industry. Furthermore, if created correctly, 3D models are more accurate than 2D drawings because they rely on exact dimensions and geometries. (Post)

The following discussion will focus on streamlining the structural steel design to construction through the implementation of computer modeling. A discussion of how to take advantage of current technology to help a project team will also be addressed.

3.0.2.A *Significance*

In July 2005, the General Services Administration (GSA) announced that all new projects requiring their funding will need to include a building information model (BIM) as part of the project proposal. The term BIM is a relatively new term in the industry, but in the past has been noted as a project model or multi-dimensional (MD) modeling. Essentially a building information model is an intelligent 3D CAD model with information attached to all items drawn in the 3D space. No longer are items just colored blocks, but with BIM these items are objects with data association. This is apparent with a 3D structural steel BIM with the fact that the 3D objects are modeled as scalable W members, steel type, connection type, along with many other inputted properties. Furthermore, risk is reduced by developing 3D models of structures at the very beginning of projects. These models reflect the entire geometry and connectivity of the structure. [Hamburg, et.al]



The GSA's requirement with a BIM needed for all of their future projects is a new approach to project design and delivery. In the past, many projects have been designed in three dimensions, but have not included the object properties which would make it a BIM. Computer aided project development has been in the industry for quite some time, however implementing it has been a hardship. Many owners, architects, and construction managers have not seen the value that these models can bring to a project mostly due to initial costs and time to develop the models.

Furthermore, NIST recently completed a study on the costs of inadequate interoperability in U.S. Capital Facilities Industry with a stunning figure of \$6.8 billion dollars lost due to poor interoperability during construction. The added expenses are partly due to manual reentry of data and request for information management which can be directly associated with the steel construction phase. (Jun et.al)

The steel construction industry is a technological savvy industry and a very important part of the United States economy. Structural steel fabrication and erection contributed 8.5 billion dollars of production and half of million workers from a 1999 and 2001 survey. (Eastman, et.al) For many years, steel detailers and fabricators have used computer software to generate documents that could be used in fabrication with computer numerically controlled (CNC) equipment. Many projects contain 3D steel structures modeled by the steel contractor which take time to develop.

3.0.2.B Objectives

This research will focus on streamlining the structural steel design to construction through the implementation of computer modeling. A better understanding of BIM will be found through the development of a steel building information model for the steel structure of the *Penn State Ballpark*.

The goals and objectives of this research are to answer the following questions:

1. Can the construction industry reduce the waste in the steel shop drawing process through implementing building information modeling?
2. What are the challenges to implementing this technology on a project?
3. How can a project team implement building information modeling on a project, specifically the steel phase?

By analyzing existing practices during the steel phase of a project, this paper will propose a more streamline process for the steel phase of a project through computer modeling.

3.0.3 CHAPTER 2
Research Approach

In order to propose a more streamline process for the steel phase of a project through computer modeling, a current understanding of steel design and construction practice must be analyzed. The research methods included journal and industry article reviews, telephone interviews with steel industry professionals, and the development of a steel BIM for *Penn State Ballpark*. Additional information regarding BIM was collected through class and industry presentations during the spring semester (2006).

3.0.3.A Research Means and Methods

The initial research included journal and industry article reviews. Most of the literature was accessed through the *American Institute of Steel Construction* or from the *National Institute of Standards and Technology’s Building Fire and Research Laboratory*. Additional articles were found through *Engineering News Record* and steel construction industry standards books (CIS/2). A more detailed understand of literature can be found in the literature review, 3.0.4.

The majority of my research information came from phone interviews with steel industry professionals. A method was needed to collect to data to understand the current practice related to design and construction in the steel industry. An interview method was chosen because more value would be achieved through direct discussions than a survey method. Furthermore, the interview technique allowed for more in depth discussions to be addressed depending on the response to interview questions. From discussions with professors, contacts from printed articles, and past interaction with industry members, industry organizations, structural engineers, steel fabricators, and construction managers were contacted about participating in an interview. The initial contact was generated through electronic mail with an attached cover letter which described the research objective. The only group that was strategically chosen for participation was the fabricators. The goal with the fabricator interview set-up was to interview a smaller, medium size, and large steel fabricator. The following table states the industry members that agreed to participate in an interview to help foster a better understand regarding steel design to construction process.

Contact Name	Group	Company
Ron Sinopoli	Construction Manager	Barton Malow Company
Ryan Maibach	Construction Manager	Barton Malow Company
Erleen Hatfield	Design Firm	Thorton-Tomasetti
Kevin Fast	Design Firm	HOK Sports
Nathan Appleman	Design Firm	HOK Sport
Babette Freund	Fabricator	Ritner Steel
Mark Holland	Fabricator	Paxton & Vierling Steel Co.
Glenn Sherrill	Fabricator	Steelfab of Alabama, Inc.
Charlie Carter	Industry Organization	AISC
Robert Lipman	Industry Organization	NIST



After an initial response from the listed industry professionals, a date and time for a telephone interview was established along with forwarding a series of question to be addressed in the interview. As found in the *Appendix – Streamlining Structural Steel Design & Construction through Computer Modeling*, a standard set of interview questions was generated for each important role in the steel design and construction phase. Each interview contained approximately ten (10) questions and the interview discussion was limited to thirty (30) minutes. It is important to note that the same questions were not asked during each interview; some questions did not pertain to each steel phase entity. For example, a designer was not asked about steel fabrication techniques because he/she does not perform fabrication tasks.

During each interview, data was collected by importing the discussion and responses into a Microsoft word document. Interview data was not collected via tape recording nor was any confidentiality statement supplied for interviews. Upon completion of all phone interviews, each interview discussion was printed to be analyzed. From analyzing the data, seven (7) similar questions were asked of each group. The seven questions and responses were analyzed through an “information web;” the webs can be found in the *Appendix – Streamlining Structural Steel Design & Construction through Computer Modeling*. Results from the interviews were found and can be viewed in section, 3.0.5.

3.0.3.B Case Study: Penn State Ballpark

Penn State Ballpark is a current construction project at The Pennsylvania State University. The project cost is \$30.9 million with construction duration of twelve (12) months. The structure for the *Ballpark* is structural steel (550 tons) with masonry load bearing walls. In order to better understand building information modeling, a structural BIM was created of *Penn State Ballpark* using Revit Structure 2. Revit Structure 2 was chosen because of past familiarity with Revit Building and ease of interoperability between AutoCAD programs. Revit Structure 2 also has already preloaded all of the structural members found in the current *AISC Manual of Steel Construction*. All of the 2D structural drawings from AutoCAD were obtained from the architectural firm and imported into Revit Structure 2 to ease in the modeling process.



3.0.4 CHAPTER 3

Literature Review

Currently, there has been a lot of research devoted to computer aided design/construction research. Most of this research is based on project case studies and not how to effectively implement computer aided models on a construction project. Many projects are documented with a 3D model which is made during the preconstruction phase of a project. These models are used to develop a rendering of the project which is mainly used for marketing purposes. Unfortunately, these models are 3D models and not building information models. Furthermore, these models are very rarely taken from the design phase of a project and implemented in the construction phase.

However, several projects are beginning to implement steel building information models and reaping the benefits as a result of the implementation. On a recent three school design-build project, RAMSteel was used to create a design model and transferred to the steel detailer to import into SDS/2 for connection design. (Gavin and Pollak) As anticipated, the project was very successful and the use of software “gave the engineers more confidence that the design was carried through.” Unlike many case studies and discussions with engineers, a model can be an advantage to an engineer and not necessarily fee related and unwillingness to cooperate by developing a design model.

An underlying belief is that more risk is associated with implementing and transferring data with a building information model on a project. However, Fowler recently completed a hospital project in which BIM implementation proved to be very successful. He found through the process “as long as the proper checks are in place and each party understands what is expected from the other, any potential added risk can be eliminated.” (Fowler)

The “poster” project for implementing a steel building information model and then transferring the data to the steel contractor is the 13,000 ton steel renovation project at Soldier Field in Chicago, IL. Thornton-Tomasetti Engineers took the lead to create a 3D design data model and share with the steel fabricator which allowed them to detail connections more easily. “The steel detailer simply enhances the engineer’s design model by adding all the elements such as bolt holes, bolts, angles and plates required for fabrication and erection.” (Post) Furthermore, model reviews on the project were implemented to lessen the paper trail associated with the shop drawing process.

Carrato et.al lists significant cost and schedule benefits for the use of 3D model data; however, this requires redefining business practices. Hatch has turned to a paperless project delivery system which reduces the project schedule by 4-8



weeks. There time was spent on perfecting the model and checking accuracy and makes the steel design process faster and error-free. (Coleman) The paperless process eliminates a lot of waste. There are fewer mistakes, less waste of steel, and less time and money wasted. (Pollak) By allowing fabricators to use the design model as the foundation for faster, more accurate shop drawing creation and manufacturing, you significantly reduce errors, provide better communication between engineers and fabricators, receive fewer RFI's, and a happier client. (Karp et.al) Until the entire project team can see direct benefits in the creation of a project model, there will not be acceptance of this new way of doing business. Another obstacle with universal acceptance is that a lot of the project team members are still living in a 2D world, and are not prepared to spend the extra money or train their people in 3D design techniques. (Engler)

3.0.5 CHAPTER 4

Research Findings

The following sections describe the results from interviews with steel construction industry professionals as well as documents the effects of a building information model with the *Penn State Ballpark* project.

3.0.5.A *Interview Results*

Interviewing industry professionals proved to be a very valuable method to fully understanding the steel design to construction process. Each industry professional was very helpful and insightful with responding and adding to the proposed interview questions. After analyzing the responses from the four interview groups, seven (7) similar questions answered by all four groups were found. The seven similar questions found are as follows:

- Have the development of steel design/shop drawings changed over the past five (5) years? (3D modeling, etc.)
- Has 3D modeling/BIM changed the steel shop drawing development and review process?
- Describe some common problems during the development of shop drawings.
- Describe the communication techniques between the designer and detailer during the shop drawing development process.
- What are the barriers to implementing building information modeling (BIM) on a project? (cost, time, legal, etc.)
- Describe the ideal steel shop drawing review process.
- Do you think the design to construction process will change in the next few years? If so, how?

The other questions that were asked added value to understanding the steel design and construction process and did not directly affect each interviewed group. Common responses for the seven similar questions are listed below:

- Have the development of steel design/shop drawings changed over the past five (5) years? (3D modeling, etc.)
 - Hand drawing to Automation
 - 3D Shop Drawing Models linked to CNC Equipment
 - 3D Design Model Given to Contractors for Bidding
- Has 3D modeling/BIM changed the steel shop drawing development and review process?



- Defined Scope with BIM During Design
- Model Reviews Instead of Drawing Reviews are Becoming More Common
- Models Exported Directly to CNC Equipment
- Describe some common problems during the development of shop drawings.
 - Model Maintenance and Discipline
 - Architectural Changes During Approval Process
 - Incomplete Design Documents
 - Coordination with Architectural Documents
- Describe the communication techniques between the designer and detailer during the shop drawing development process.
 - Rarely Direct Contact between Designer and Detailer
 - Attach Screen Shot of Model to Requests for Information (RFI)
- What are the barriers to implementing building information modeling (BIM) on a project? (cost, time, legal, etc.)
 - Different Way Of Thinking
 - Fee Issues with More Design Services
 - Accuracy of Model
 - Interoperability
 - Understanding How BIM Benefits Project Team
- Describe the ideal steel shop drawing review process.
 - Coordinated Team
 - Decisions Made Instead of Delay Decision Making
 - Software Easily Exchange Information
 - Model Review Instead of Paper Drawings
 - Information Exchanged Electronically
- Do you think the design to construction process will change in the next few years? If so, how?
 - Software Companies Forming More Strategic Alliances
 - 3D Steel Shop Drawing Model Review Meetings
 - Interoperability Will Determine the Change to Construction Process.

Please consult *Appendix – Streamlining Structural Steel Design & Construction through Computer Modeling* for a detailed depiction of each questions response.



While performing the research interviews, it became apparent that the overwhelming feeling is very positive with implementing such technology during the steel phase. The question then becomes, how do we use the technology to have a successful project? The following table outlines the most common challenges associated with BIM on the steel phase of a project and gives a control method to overcoming challenges.

BIM for Steel Phase on a Project	
Challenges	Control Method
Contract Language	AISC Code of Standard Practice (Chapter 16) assists with correct verbage.
Design Management	Design decisions made sooner. Better design coordination through a design model.
Technology	Choose up-to-date software with most effective data exchanging capabilities. CIS/2 continues to help with exchanging data between software will become less of a problem. Create an FTP site to post all documents to be exchange electronically.
Communication	Promotes constant communication and project understanding by project team.
Paper Drawings	3D Model reviewed and approved. Erection Drawings Only.

These challenges include contract language, design development and management, technology, communication with project team members, and the issuing of hard copy (paper) drawings. The control methods listed on the right describe ways to overcome the challenges and allow a project to benefit from the use of building information modeling.

Ideas to overcoming the challenges of technology have already been implemented on school projects where several of the projects shop drawings were reviewed using a projects intranet server. (Garvin and Pollak) The concern with technology is the directly related to interoperability which is integrating design and construction processes by eliminating the need for manual re-entry of data. (Ruby) Manual re-entry is becoming less of a hassle with data exchange methods between software programs through the CIMsteel Integration Standards (CIS/2). The CIS/2 standards are a set of formal computing specifications that allow software vendors to make their engineering applications compatible. (Danso-Amoako et. Al)

3.0.5.B Case Study Results: Penn State Ballpark

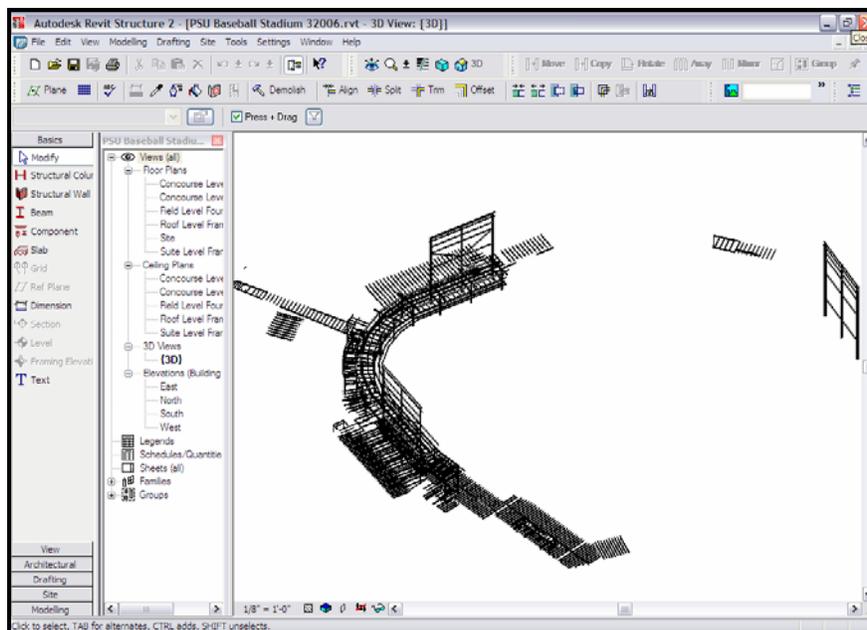
Using the *Penn State Ballpark* as a case study project, a BIM was generated for the steel phase of the project using Revit Structure 2. There were several reasons in choosing to generate a BIM. One, it is important to understand how such a



model is created and how to use the software in which a model is created. Another reason was to find if there are any direct problems with the current software used for structural building information modeling. A better understanding of the structural design and seeing if there was any direct design conflicts wanted to be observed. If the information on the contract drawings is incomplete or inaccurate, then the building cannot be built either in the computer or in the field. (Trincher) Lastly, a better understanding of BIM wanted to be created to construction industry members through an actual project. The table below documents information pertaining to the BIM created for *Penn State Ballpark*.

Case Study BIM Model
Revit Structure 2
65 Hours to create BIM.
Some areas could not be modeled.
Known steel quantities with schedules.

The baseball stadium geometry is fairly simple; however it was difficult to model some areas of the structure. For example, not all of the angled roof beams could be created due to the angle of the members. Most of the modeling went smoothly minus those few heartaches that took some time to try and solve. All in all, the model took sixty-five (65) hours to develop which is about 8 working days. This number is also somewhat skewed because of being a new user with the modeling software. Below is a screen shot of the model created in Revit Structure 2.





This can be compared to the SDS/2 fabrication model depicted below. At the fabrication, more detail is needed regarding connections and fabrication length but a “similar” model is generated.



Model Courtesy of Ritner Steel, Inc.

The geometry alone with a fabrication model can take a week or two to create before detailing begins. The *Penn State Ballpark* project is a fast-track, design-bid-build delivery system with construction duration at 12 months. As with most stadium projects, the steel structure is very vital to finishing the project on time and therefore is on the critical path. Any time that can be saved during “non-construction” activities will add time value savings to the construction activities. Consequently, developing a structural design BIM and giving the model to the awarded steel contractor would allow the detailing process to begin sooner. This is due to the fact that the contractor does not have to take the time to regenerate the column lines along with each steel member; more value can be associated with connection design.

As stated earlier, the steel shop drawing approval process is often time consuming typically taking several weeks with this project being no exception. In order to begin steel erection on November 1, 2005, the first three steel sequences needed to be approved by August 1, 2005. This gave the steel contractor four (4) weeks from award to develop and submit for approval the first three sequences of shop drawings. With the statements made earlier, it often takes a week or so to get the detailing software set-up with the initial structural information before detailing can begin. If a BIM was given to the steel contractor, detailing of the structure



could have begun immediately instead of time “wasted” during the creation of the building geometry and designed structural members.

A design to construction BIM will also help manage the request for information process. As of March 31, 2006 there were 650 RFI’s on the project with 115 of the RFI’s related to the steel construction phase. Through the CIS/2 standards, fewer requests for information will result or the requests will be coordinated and managed at one time rather than trickling in over a long period of time. (Carato et.al) This would allow the construction engineer to spend more time with other phases of a project and not be tied down with an extravagant amount of steel RFI’s.

Furthermore, a BIM will give each project team member a better understanding of the structure and supply valuable information to the construction team. One example of this is the ability to create quantity schedules with the creation of a BIM. Because data is linked with each item drawn with BIM software, creating column, beam, and joist schedules is very easy. Unfortunately, the construction team was not supplied with a column schedule for the project. This presented a problem during the bidding period and also during construction. On the design documents, base plate elevations were mislabel 100’-0” and caused many questions regarding column lengths for bidding purposes. Furthermore, a column schedule is important to the construction team to be able to verify building height and determining scheduling activities. By using BIM, a column schedule is created instantaneously when drawing the structure. Below are three schedules created from the building information model in Revit Structure 2.

Sample Quantity Schedules Created in Revit Structure 2

Penn State Ballpark <i>Structural Column Schedule</i>						
Column Description	Quantity	Length	Base Level	Base Offset	Top Level	Top Offset
W14X90	1	118' - 6"	Concourse Level Framing Plan	-14' - 6"	Roof Level Framing Plan	75' - 0"
W14X43	1	15' - 9 1/2"	Field Level Foundation Plan	-1' - 6"	Concourse Level Framing Plan	-0' - 8 1/2"
W14X132	1	120' - 6"	Field Level Foundation Plan	-1' - 6"	Roof Level Framing Plan	75' - 0"
W14X43	1	15' - 8"	Field Level Foundation Plan	-1' - 6"	Concourse Level Framing Plan	-0' - 10"
W14X90	1	120' - 6"	Field Level Foundation Plan	-1' - 6"	Roof Level Framing Plan	75' - 0"

Penn State Ballpark <i>Structural Beam Schedule</i>			
Beam Description	Quantity	Length	Reference Level
HSS-Hollow Structural Section: HSS5X5X.1875	1	7' - 6 1/2"	Concourse Level Framing Plan
W-Wide Flange: W10X12	1	18' - 1 7/32"	Concourse Level Framing Plan
W-Wide Flange: W10X12	1	18' - 7 1/32"	Concourse Level Framing Plan
W-Wide Flange: W12X14	1	24' - 7 5/16"	Concourse Level Framing Plan
W-Wide Flange: W12X19	1	11' - 5 27/32"	Concourse Level Framing Plan



Penn State Ballpark <i>Structural Joist Schedule</i>			
Joist Description	Quantity	Length	Reference Level
LH-Series Bar Joist: 18LH02	1	16' - 10"	Concourse Level Framing Plan
LH-Series Bar Joist: 18LH02	1	16' - 10"	Concourse Level Framing Plan
LH-Series Bar Joist: 18LH02	1	16' - 10"	Concourse Level Framing Plan
LH-Series Bar Joist: 18LH02	1	16' - 8 3/32"	Concourse Level Framing Plan
LH-Series Bar Joist: 18LH02	1	16' - 8 3/32"	Concourse Level Framing Plan

A case study with the *Penn State Ballpark* project examined the effects a BIM could have on a better delivery on the design and expediting the steel shop drawing duration with a building information model supplied by the structural engineer. The implementation of such a model benefits each project team member from design to construction.



3.0.6 CHAPTER 5

Conclusion

By implementing building information modeling during the design phase, the time invested during the shop drawing phase can be decreased. On a recent casino project, using CIS/2 translators, a [design model] was imported into SDS/2 detailing software package and was able to detail and finish the first sequence of fabrication in just 19 days. Without this exchange capability, this project would have taken an additional four weeks to complete. (Melnick) From interview discussions with steel construction industry professionals, there are several challenges to implementing this technology. These challenges include contract language, design development and management, technology, communication with project team members, and the issuing of hard copy (paper) drawings. With the stated challenges, a proposed method to addressing the challenge is expressed.

A case study with the *Penn State Ballpark* project examined the effects a BIM could have on a better delivery on the design and expediting the steel shop drawing duration with a building information model supplied by the structural engineer.

More research should be examined with implementing full-scale building information models on projects. The literature review analyzed several projects that have implemented a BIM, but more attention should be addressed to how these projects were successful. Further research can also be analyzed with coordination between various fabricators involved with the structural package. There is often improper coordination between metal deck, metal joists, and structural steel which leads to fabrication and construction delays. It is possible with BIM that the improper document coordination methods can be eliminated. The steel phase is very dependent on exact dimensions for fabrication purposes and building information can only help this area of a project. Furthermore, BIM is estimated to reduce detailing costs by 50%, 10%-20% reduction in shop production costs, and 50% to 80% reduction in estimating costs. (Hamburg)

Construction industry trends will show more and more projects implementing this technology over the next few years. The CIS/2 modeling standards will help software developers implement the proper exporting capabilities to make different software packages interoperable with each other.

By analyzing existing practices during the steel phase of a project, a more streamline process for the steel phase of a project through computer modeling has been addressed. The above research discussion has benefited structural designers, construction managers, and steel fabrication because each entity can more effectively perform his/her job with the implementation.



SUMMARY AND CONCLUSIONS

The structural analysis proved that an alternative column design could be used and is a positive value engineering suggestion for the project. It provides an overall cost savings of \$45,184.20 in labor, material, and equipment and a schedule savings of 7 days on erection of the columns. Through this analysis several advantages were noted including added waterproofing and easier electrical cable installation to the power the field lighting fixtures. The only noted disadvantage with the alternative column design is that the additional welding expertise to fabricate a “custom” column could limit the amount of steel fabricator’s willing to bid the work. By performing this analysis, I was able to successfully provide an alternative design and satisfied the goals associated with the analysis. This analysis is a valuable tool for a construction manager to be able to discover. An understanding of the cost and benefits to changing a structural column can help identify alterations of future projects.

The electrical analysis proved that an alternative system is a positive value engineering suggestion for the project. It provides a cost savings of \$8,771.38 in labor and material but most importantly the alternative system will provide the owner better electrical maintenance means during the building lifetime. Furthermore, the ease of expansion within the retail building will be much easier with the alternative system because wires and conduit do not need to be installed 275’ away from the source of expansion. This analysis is a valuable tool for a construction manager to be able to utilize when providing value engineering suggestion to an owner. An understanding of the cost and benefits to modifying an electrical system can help identify alterations of future projects. Overall, the alternative system is a very positive electrical value engineering suggestion for the owner and will provide positive effects during the building operation.

The construction industry research topic regarding streamlining the steel design and construction through computer modeling proved to be very information and worthwhile. From interview discussions with steel construction industry professionals, there are several challenges to implementing this technology. These challenges include contract language, design development and management, technology, communication with project team members, and the issuing of hard copy (paper) drawings. With the stated challenges, a proposed method to addressing the challenge is expressed. A case study with the *Penn State Ballpark* project examined the effects a BIM could have on a better delivery on the design and expediting the steel shop drawing duration with a building information model supplied by the structural engineer. By analyzing existing practices during the steel phase of a project, a more streamline process for the steel phase of a project through computer modeling has been addressed. The research discussion has benefited structural designers, construction managers, and steel fabrication because each entity can more effectively perform his/her job with the implementation.

Streamlining the Steel Design and Construction Through Computer Modeling

Appleman, Nate, and Kevin Fast. Telephone interview. 22 Feb 2006.

Carrato, Pete, and Mark Holland. "Business Practices in a 3D Structural Model Environment: How do They Effect the Steel Designer and Detailer." Structures 2004.

Carter, Charlie. Telephone interview. 7 Mar 2006.

Coleman, Gabriel. "Hatch Utilizes EDI Technologies for Paperless Project Delivery."

Cross, J.P. C.M. Hewitt. M.J. Horman. and M.H. Pulaski. "Steel Fabricator Involvement in Project Design."

Crowley, Dr. Andrew. "The Evolution of Data Exchange Standards: The Legacy of CIMSteel."

Danso-Amoako, Mark, William O'Brien, and Raja Issa. "A Case Study of IFC and CIS/2 Support for Steel Supply Chain Processes." 29 Jan 2006.

Eastman, Chuck. Rafael Sacks. and Ghang Lee. "Strategies for Realizing the Benefits of 3D Integrated Modeling of Building for the AEC Industry."

Engler, Don. "Integrated Steel Design: The Engineers Role." STRUCTURE July 2004.

"Exchange Capabilities." CIS2@GT. Georgia Tech College of Architecture. 31 Jan. 2006 <<http://www.coa.gatech.edu/~aisc/index.php?cat1=1>>.

Foster, Joele. "Buidling Better." Modern Steel Construction June 2003.

Freund, Babette. Personal interview. 7 Mar 2006.

Garvin, Edward, and Beth Pollak. "3 Schools + 2 Years = 1 Team." Modern Steel Construction October 2003.

Hamburg, Steven, and Mark Holland. "Leaping Ahead with EDI." Modern Steel Construction February 1999.

Hatfield, Erleen. Telephone interview. 8 Feb 2006.

Streamlining the Steel Design and Construction Through Computer Modeling

Holland, Mark. Telephone interview. 24 Feb 2006.

Jun, Joseph, and Gabriel Coleman. "Interoperability and the Construction Process: A White Paper for Building Owners and Project Decision-Makers."

Karp, Raoul, and Brian Quinn. "Computer Aided Design: More than Just an Electronic Pencil and Paper." STRUCTURE July 2004.

Lipman, Robert. "Mobile 3D Visualization for Construction."

Lipman, Robert. Telephone interview. 23 Feb 2006.

Lipman, Robert. "Visualization of Structural Steel Product Models." May 2003 <<http://www.itcon.org/2003/5>>.

Maibach, Ryan. Telephone interview. 9 Feb 2006.

Melnick, Scott. "Engineers a Turn to EDI for Cost Savings." Structure Dec/Jan 2001.

Nadine, Post. "Digital Model: Stadium Engineer Drives Toward 'Paperless' Project." ENR April 14 2003.

Nadine, Post. "Digital Model: Steel Sector Plans Paradigm Shift." ENR April 14 2003.

Pollak, Beth. "Steel Goes Global." Modern Steel Construction December 2003.

Robinson, Clive, and Rhett Thompson. "Advancements in Data Exchange: The Integrated Model Approach – Multi-Material & Multi-Discipline." STRUCTURE July 2004.

Ruby, David. "Ruby on Interoperability."

Sherrill, Glenn. Telephone interview. 15 Feb 2006.

Sinopoli, Ron. Telephone interview. 10 Mar 2006.

Trincherro, . "Information Technology in the Steel Industry." SAICE IT. 31 Jan. 2006 <<http://www.saice-it.co.za/web/SAISC-SAICE-Paper.htm>>.

APPENDIX

STREAMLINING THE STRUCTURAL STEEL DESIGN & CONSTRUCTION THROUGH COMPUTER MODELING



***STREAMLINING THE STRUCTURAL STEEL DESIGN &
CONSTRUCTION THROUGH COMPUTER MODELING
RESEARCH COVER LETTER***

My name is Jason McFadden and I am currently a senior architectural engineering student pursuing an integrated bachelor and master degree in the construction management option. I am performing a senior capstone project which is related to a current construction project in the industry. Part of my project is a research study related to “Streamlining the Superstructure Design and Construction through Computer Modeling.”

The goal of this research project is to address the following questions:

1. Can the construction industry reduce the waste in the steel procurement process through implementing building information modeling (BIM)?
2. Can BIM help with fabrication coordination (supply-chain management) between the structural steel, decking, and joist suppliers?

By analyzing existing practices (design, shop drawings, and coordination) during the steel phase of a project, I will propose a more streamline process for the steel phase of a project.

By evaluating the efforts to streamlining the superstructure design & construction through computer modeling, I aim to address better techniques in going from the structural design to the fabrication stage and erection of steel in this project. Because the steel phase of a project is often on the critical path, any time that might be able to be saved could result in a quicker delivery of the entire project. Upon completion, this research will benefit structural designers, construction managers, and steel fabricators as well as leave ideas for continued research in streamlining the design to construction of the structural sequence. Furthermore, I will be able to address better coordination techniques between steel suppliers.

By responding, I would like to schedule a thirty-minute phone conversation to discuss this study. Please let me know your availability. Thank you in advance for taking the time to participate in this study. Your insight will allow for a better understanding of the current problems associated with this topic. Please feel free to contact me should you have any other questions.

Respectfully,

Jason McFadden

The Pennsylvania State University
Integrated Bachelor and Master of Architectural Engineering candidate
Phone: (610) 914-8346
Email: jem358@psu.edu
<http://www.arche.psu.edu/thesis/eportfolio/current/portfolios/jem358/>

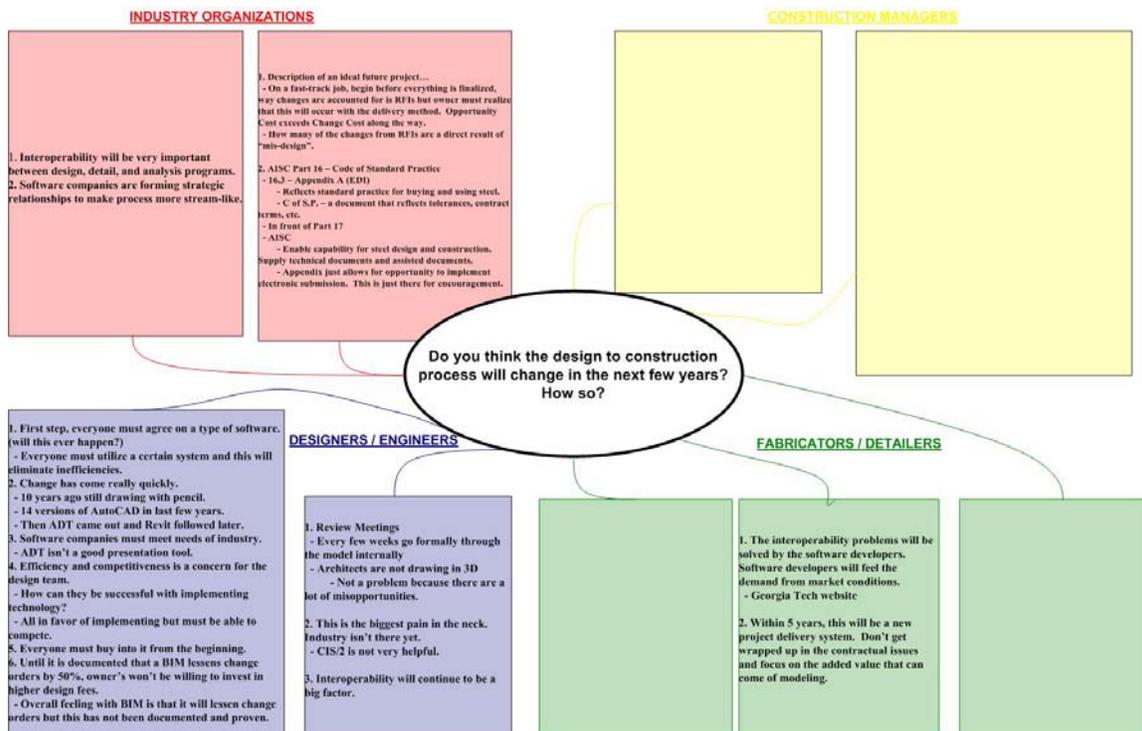


***STREAMLINING THE STRUCTURAL STEEL DESIGN &
CONSTRUCTION THROUGH COMPUTER MODELING
CONFERENCE CALL INTERVIEW SCHEDULE***

Contact Name	Group	Company	Conference Date and Time	Phone	Email
Ron Sinopoli	Construction Manager	Barton Malow Company	3/10/06 - - 11:00am (EST)	(434) 455-2447	ron.sinopoli@bartonmalow.com
Ryan Maibach	Construction Manager	Barton Malow Company	2/9/06 - - 10:30am (EST)	(734) 732-0934	ryan.maibach@bartonmalow.com
Erleen Hatfield	Design Firm	Thorton-Tomasetti	2/8/06 - - 2:00pm (EST)	(917) 570-6700	ehatfield@ttengeers.com
Kevin Fast	Design Firm	HOK Sports	2/22/06 - - 3:00pm (EST)	(816) 221-1500	kevin.fast@hok.com
Nathan Appleman	Design Firm	HOK Sport	2/22/06 - - 3:00pm (EST)	(816) 221-1500	nathan.appleman@hok.com
Babette Freund	Fabricator	Ritner Steel	3/7/06 - - 12:30pm (EST)	(717) 249-1449	bfreund@ritnersteel.com
Mark Holland	Fabricator	Paxton & Vierling Steel Co.	2/24/06 - - 3:30pm (EST)	(712) 347-4260	mvholland@compuserve.com
Glenn Sherrill	Fabricator	Steelfab of Alabama, Inc.	2/15/06 - - 12:30pm (EST)	(770) 248-0075	gsherrill@steelfab-inc.com
Charlie Carter	Industry Organization	AISC	3/7/06 - - 10:00am (EST)	(312) 670-5414	carter@aisc.org
Robert Lipman	Industry Organization	NIST	2/23/06 - - 10:00am (EST)	(301) 975-3829	robert.lipman@nist.gov

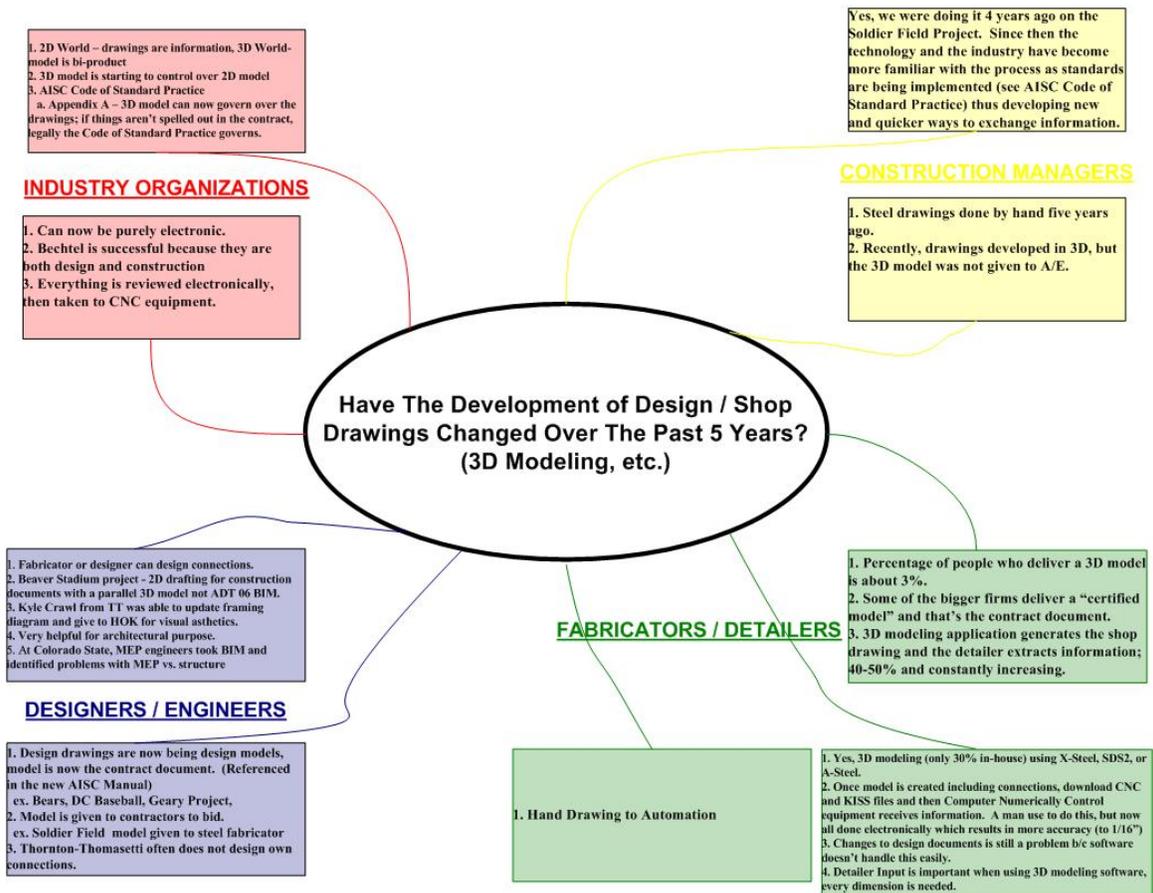


**STREAMLINING THE STRUCTURAL STEEL DESIGN & CONSTRUCTION THROUGH COMPUTER MODELING
COMPILED INTERVIEW RESPONSES**



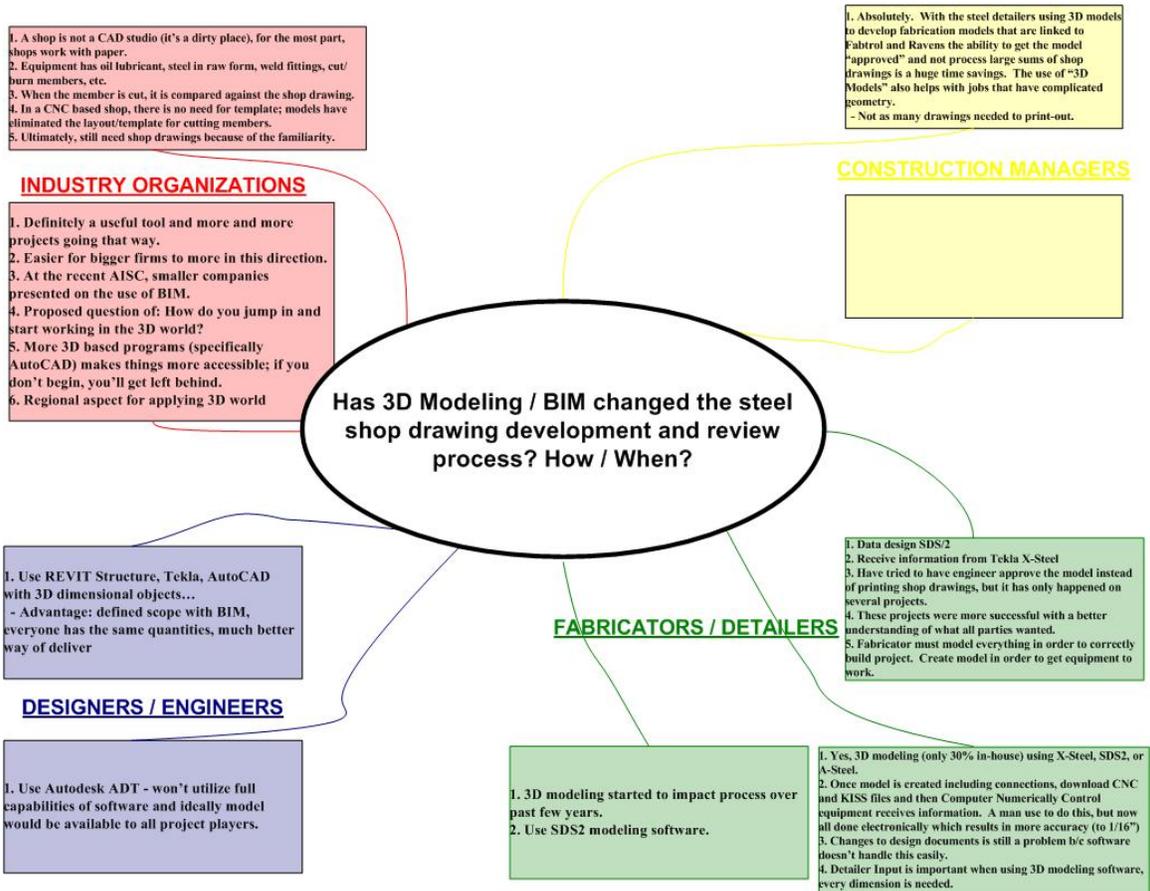


STREAMLINING THE STRUCTURAL STEEL DESIGN & CONSTRUCTION THROUGH COMPUTER MODELING
COMPILED INTERVIEW RESPONSES



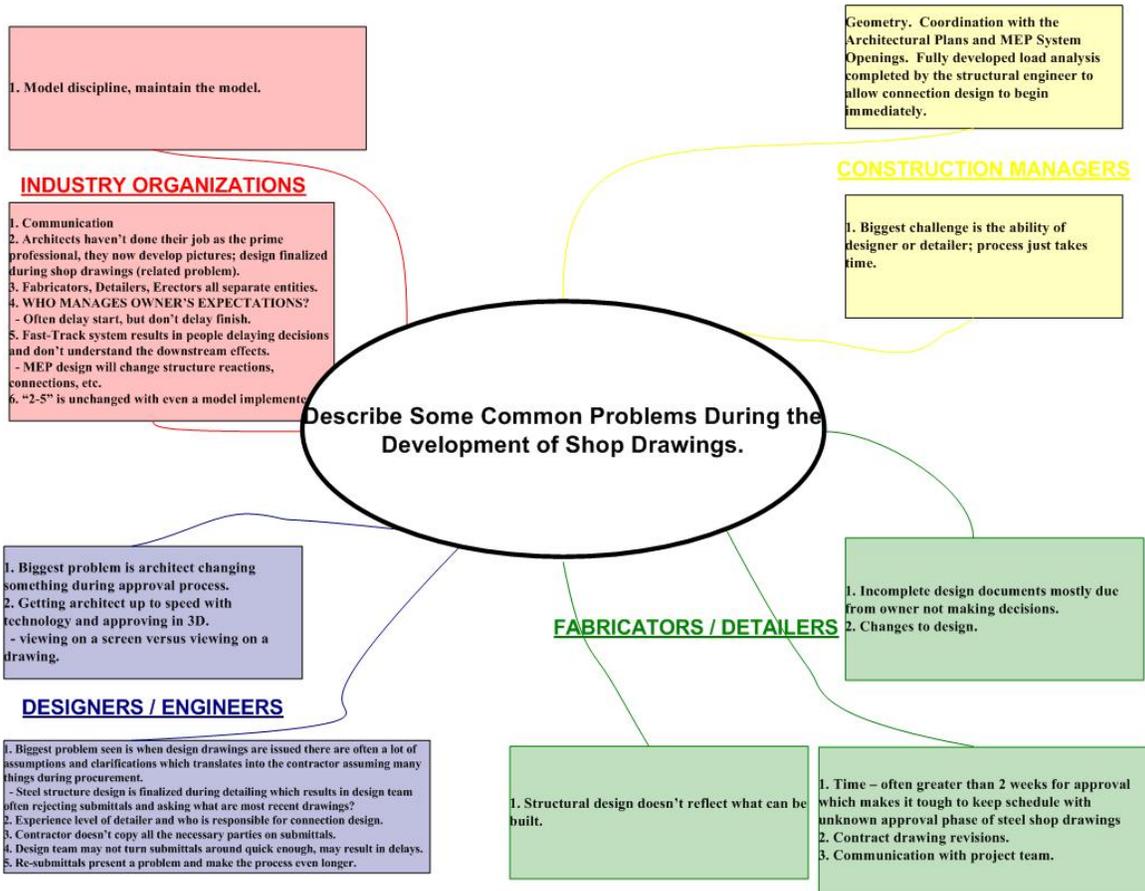


STREAMLINING THE STRUCTURAL STEEL DESIGN & CONSTRUCTION THROUGH COMPUTER MODELING
COMPILED INTERVIEW RESPONSES



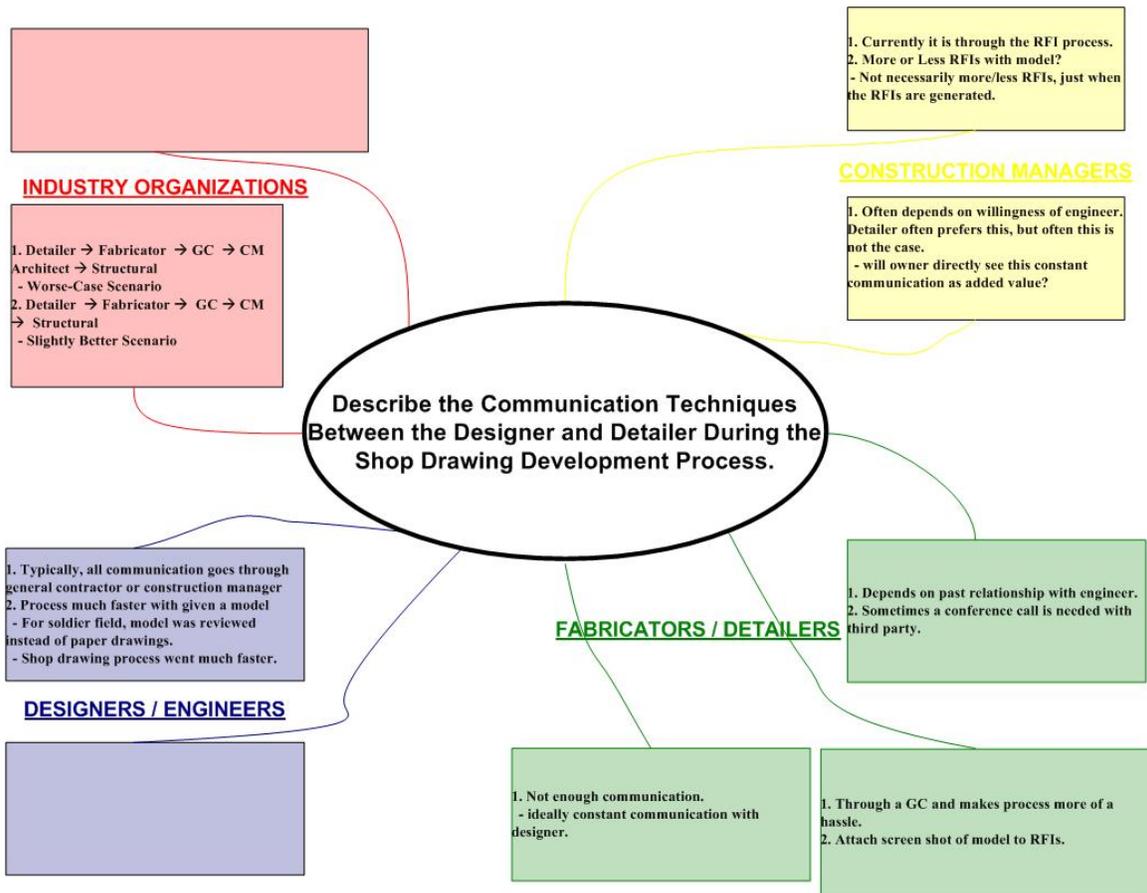


**STREAMLINING THE STRUCTURAL STEEL DESIGN & CONSTRUCTION THROUGH COMPUTER MODELING
COMPILED INTERVIEW RESPONSES**



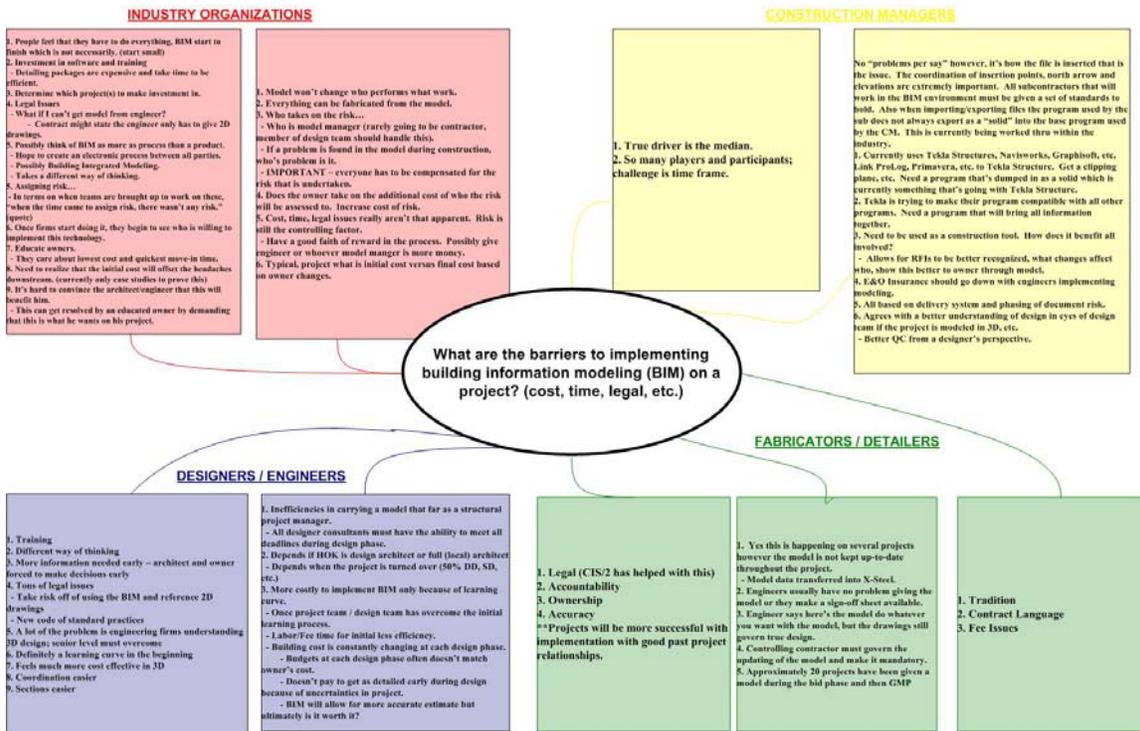


STREAMLINING THE STRUCTURAL STEEL DESIGN & CONSTRUCTION THROUGH COMPUTER MODELING
 COMPILED INTERVIEW RESPONSES



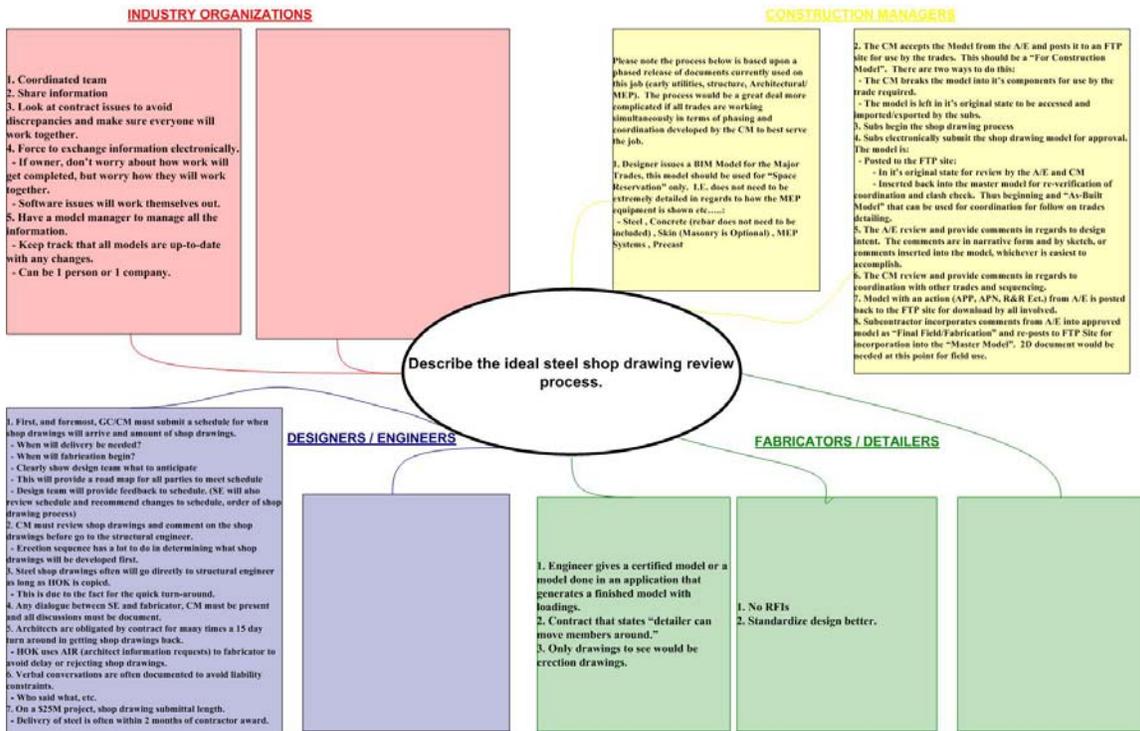


**STREAMLINING THE STRUCTURAL STEEL DESIGN & CONSTRUCTION THROUGH COMPUTER MODELING
COMPILED INTERVIEW RESPONSES**





**STREAMLINING THE STRUCTURAL STEEL DESIGN & CONSTRUCTION THROUGH COMPUTER MODELING
COMPILED INTERVIEW RESPONSES**



SAMPLE INTERVIEW QUESTIONS

***STREAMLINING THE STRUCTURAL STEEL DESIGN &
CONSTRUCTION THROUGH COMPUTER MODELING
STEEL INDUSTRY/RESEARCH ORGANIZATION***

1. Have the development of shop drawings changed over the past five years? (3D modeling, etc.)
2. When did 3D modeling start to impact the process (if at all)?
3. How has digital fabrication changed the steel shop drawing development process?
4. What phase of a project does the steel detailer become involved? Does this ever occur during the structural design phase?
5. Describe the communication techniques between the designer and detailer during the shop drawing development process.
6. Describe some common problems during the development of shop drawings.
7. If a structural engineer develops the steel design in 3D will this benefit the detailer at all? If so, how? Also, are there any problems with an engineer developing the design in 3D?
8. What are the barriers to implementing building information modeling (BIM) on a project? (cost, time, legal, etc.)
9. Who typically manages the supply-chain between all the different entities associated with the steel phase of a project? Does their role change with BIM?
10. If you experience problems exchanging data between applications, do they use CIS/2 files? Do you think the design to construction process will change in the few years? If so, how?
11. Describe the ideal steel shop drawing review process.



Robert Lipman (NIST)
(301) 975-3829

February 23, 2006
10 A.M. EST

***STREAMLINING THE STRUCTURAL STEEL DESIGN &
CONSTRUCTION THROUGH COMPUTER MODELING
STEEL INDUSTRY/RESEARCH ORGANIZATION***

1. Have the development of shop drawings changed over the past five years? (3D modeling, etc.)
 - a. Never been in construction industry, research has been involved with this area over the past few years.
 - b. 2D World – drawings are information
 - c. 3D World- model is bi-product
 - d. 3D model is starting to control over 2D model
 - e. AISC Code of Standard Practice
 - i. Appendix A – 3D model can now govern over the drawings.
 - ii. If things aren't spelled out in the contract, legally the Code of Standard Practice governs.

2. When did 3D modeling start to impact the process (if at all)?
 - a. Definitely a useful tool and more and more projects going that way.
 - b. Easier for bigger firms to move in this direction.
 - c. At the recent AISC, smaller companies presented on the use of BIM.
 - i. How do you jump in and start working in the 3D world?
 - d. More 3D based programs (specifically AutoCAD)
 - i. Makes things more accessible.
 - ii. If you don't begin, you'll get left behind.
 - e. Regional aspect for applying 3D world

3. How has digital fabrication changed the steel shop drawing development process?
 - a. Shouldn't matter as long as you generate a CNC file.
 - b. GM Plant Project
 - i. Douglass Steel (detailing, fabricating, erection)
Contact: Larry Kruth (lkruth@douglassteel.com, 517-322-2050x54)
 1. received RAM model from engineer
 2. SDS/2 for detailing
 3. conscientious about keeping model updated in detailing (model detailing)
 4. fabrication process as out dated equipment
 - a. no automated equipment (equipment from 1940)
 - b. templates made from cardboard



- c. equipment costs a lot of money and requires more shop room.
 - d. This process is successful for them since 1995.
4. What phase of a project does the steel detailer become involved? Does this ever occur during the structural design phase?
5. Describe the communication techniques between the designer and detailer during the shop drawing development process.
6. Describe some common problems during the development of shop drawings.
 - a. Model discipline, maintain the model.
7. If a structural engineer develops the steel design in 3D will this benefit the detailer at all? If so, how? Also, are there any problems with an engineer developing the design in 3D?
8. What are the barriers to implementing building information modeling (BIM) on a project? (cost, time, legal, etc.)
 - a. People feel that they have to do everything, BIM start to finish which is not necessarily.
 - i. Start small.
 - b. Investment in software and training
 - i. Detailing packages are expensive and take time to be efficient.
 - c. Determine which project(s) to make investment in.
 - d. Legal Issues
 - i. What if I can't get model from engineer?
 1. Contract might state the engineer only has to give 2D drawings.
 - e. Possibly think of BIM as more as process than a product.
 - i. Hope to create an electronic process between all parties.
 - ii. Possibly Building Integrated Modeling.
 - iii. Takes a different way of thinking.
 - f. Assigning risk...
 - i. In terms on when teams are brought up to work on these, "when the time came to assign risk, there wasn't any risk." (quote)
 - g. Once firms start doing it, they begin to see who is willing to implement this technology.
 - h. Educate owners.
 - i. They care about lowest cost and quickest move-in time.
 - ii. Need to realize that the initial cost will offset the headaches downstream.
 1. currently only case studies to prove this.



2. Contact: Puma Steel
 - a. Team Puma – technology, BIM, group
 - b. They talked about smaller.
- i. It's hard to convince the architect/engineer that this will benefit him.
 - i. This can get resolved by an educated owner by demanding that this is what he wants on his project.
9. Who typically manages the supply-chain between all the different entities associated with the steel phase of a project? Does their role change with BIM?
10. If you experience problems exchanging data between applications, do they use CIS/2 files? Do you think the design to construction process will change in the few years? If so, how? Interoperability....
 - a. Autodesk Revit Structure with their definition of BIM (fairly good definition)
 - b. CIS/2 – standard for steel
 - i. Been very successful between moving files around in detailing, design, analysis, etc.
 - ii. RAM doesn't import a CIS/2 for analysis.
 3. RAM doesn't have any plans to change this.
 - iii. More software companies are starting to support CIS/2.
 - c. IFC – standard for building industry
 - i. Life cycle of building is very important but not very detailed in terms of steel.
 - ii. Packages like ArchiCAD, ADT...
 - iii. Information for the building world.
 - d. Bentley Structure (bought RAM and STAAD) supports many files natively.
 - i. Design model in Bentley and now have ability to bring into RAM for analysis.
 4. can do everything with one program similar to Tekla.
 - ii. Companies are forming strategic relationships to make process more streamlike.
 - iii. Still prioritize relationship.
 - e. More software choices now available.
 - f. Team for the project is vital.
 - i. Between owner, designer, contractor, etc.
 - g. Navisworks – ability to bring many file formats in but not import anything out.
 - h. Still many older types of software as well.
 - i. SDS/2, Fabtrol, etc.
11. Describe the ideal steel shop drawing review process.



-
- a. Coordinated team
 - b. Share information
 - c. Look at contract issues to avoid discrepancies and make sure everyone will work together.
 - d. Force to exchange information electronically.
 - i. If owner, don't worry about how work will get completed, but worry how they will work together.
 - ii. Software issues will work themselves out.
 - e. Have a model manager to manage all the information.
 - i. Keep track that all models are up-to-date with any changes.
 - ii. Can be 1 person or 1 company.

12. Words of Wisdom

- f. BIM is not drawing, drawings are just a bi-product... looking to create information not drawings.
 - i. Previously, a wall only contained dimensions, now an information model contains other properties.



Charlie Carter (AISC)
(312) 670-5414

March 7, 2006
10 A.M. EST

***STREAMLINING THE STRUCTURAL STEEL DESIGN &
CONSTRUCTION THROUGH COMPUTER MODELING
STEEL INDUSTRY/RESEARCH ORGANIZATION***

1. Have the development of shop drawings changed over the past five years? (3D modeling, etc.)
 - a. Can now be purely electronic.
 - b. Bechtel is successful because they are both design and construction.
 - i. Everything is reviewed electronically.
 - ii. Then taken to CNC equipment.
 - iii. Pete Carrato (engineer)
 5. P: 301-228-7611
 6. E: pcarrato@bechtel.com
 - c. Rex Lewis
 - i. Phone: 307-637-7177
 - ii. Email: rex.lewis@pumasteel.com
2. When did 3D modeling start to impact the process (if at all)?
 - a. A shop is not a CAD studio (it's a dirty place).
 - i. For the most part, shops work with paper.
 - b. Equipment has oil lubricant, steel in raw form, weld fittings, cut/burn members, etc.
 - c. When the member is cut, it is compared against the shop drawing.
 - d. In a CNC based shop, there is no need for template.
 - i. Models have eliminated the layout/template for cutting members.
 - e. Ultimately, still need shop drawings because of the familiarity.
3. How has digital fabrication changed the steel shop drawing development process?
 - a. See above.
4. What phase of a project does the steel detailer become involved? Does this ever occur during the structural design phase?
 - a. Model tends to force everyone to be involved earlier.
 - i. Detailer often forced to talk directly with engineer.
 - ii. Forces faster communication.
 - b. Paper tends to eliminate the detailer to become involved earlier.
 - i. Detailer often prevented to talk directly with engineer.
5. Describe the communication techniques between the designer and detailer during the shop drawing development process.



- a. Detailer → Fabricator → GC → CM → Architect → Structural
 - i. Worse-Case Scenario
 - b. Detailer → Fabricator → GC → CM → Structural
 - i. Slightly Better Scenario
6. Describe some common problems during the development of shop drawings.
- a. Communication
 - b. Architects haven't done their job as the prime professional.
 - i. They now develop pictures
 - ii. Design finalized during shop drawings (related problem).
 - c. Fabricators, Detailers, Erectors all separate entities.
 - d. ****WHO MANAGES OWNER'S EXPECTATIONS???***
 - i. Often delay start, but don't delay finish.
 - e. Fast-Track system results in people delaying decisions and don't understand the downstream effects.
 - i. MEP design will change structure reactions, connections, etc.
 - f. "B-E" is unchanged with even a model implemented.
7. If a structural engineer develops the steel design in 3D will this benefit the detailer at all? If so, how? Also, are there any problems with an engineer developing the design in 3D?
- a. See above.
8. What are the barriers to implementing building information modeling (BIM) on a project? (cost, time, legal, etc.)
- a. Model won't change who performs what work.
 - b. Everything can be fabricated from the model.
 - c. Who takes on the risk...
 - i. Who is model manager (rarely going to be contractor, member of design team should handle this).
 - ii. If a problem is found in the model during construction, who's problem is it.
 - iii. IMPORTANT – everyone has to be compensated for the risk that is undertaken.
 - d. Does the owner take on the additional cost of who the risk will be assessed to. Increase cost of risk.
 - e. Cost, time, legal issues really aren't that apparent. Risk is still the controlling factor.
 - i. Have a good faith of reward in the process. Possibly give engineer or whoever model manger is more money.
 - f. Typical, project what is initial cost versus final cost based on owner changes.



9. Who typically manages the supply-chain between all the different entities associated with the steel phase of a project? Does their role change with BIM?
10. If you experience problems exchanging data between applications, do they use CIS/2 files? Do you think the design to construction process will change in the few years? If so, how?
11. Describe the ideal steel shop drawing review process.
12. Description of project...
 - a. On a fast-track job, begin before everything is finalized, way changes are accounted for is RFIs but owner must realize that this will occur with the delivery method. Opportunity Cost exceeds Change Cost along the way.
 - b. How many of the changes from RFIs are a direct result of “mis-design”.
13. New software...
 - a. How to use technology.
 - i. Marketplace will drive technology.
 - ii. Will it increase process?
 - iii. How does it benefit daily tasks.
 - b. Autodesk Revit example (structure, building, MEP)
 - c. Someone will get into this enough and learn the lessons and others will follow.
 - d. Look at it as “Isn’t the way we use technology great.”
14. AISC Part 16 – Code of Standard Practice
 - a. 16.3 – Appendix A (EDI)
 - i. Reflects standard practice for buying and using steel.
 - ii. C of S.P. – a document that reflects tolerances, contract terms, etc.
 - b. In front of Part 17
 - c. AISC
 - i. Enable capability for steel design and construction. Supply technical documents and assisted documents.
 - ii. Appendix just allows for opportunity to implement electronic submission. This is just there for encouragement.



SAMPLE INTERVIEW QUESTIONS

STREAMLINING THE STRUCTURAL STEEL DESIGN & CONSTRUCTION THROUGH COMPUTER MODELING ARCHITECTS & STRUCTURAL ENGINEERS

1. How has your development of design drawings changed over the past five years? (3D modeling, etc.)
2. Do you currently develop a 3D model for your projects? If so what modeling software do you use? Is this model available to the contractor?
3. As a designer, what are the barriers to implementing 3D modeling/BIM on a project? (cost, time, value, legal, etc.)
4. What phase of a project does the steel detailer become involved? Does this ever occur during preconstruction?
5. Describe the communication techniques between the designer and detailer during the shop drawing development process.
6. Describe some common problems during the development of shop drawings.
7. Describe the ideal steel shop drawing review process.
8. If you experience problems exchanging data between applications, do they use CIS/2 files? Do you think the design to construction process will change in the few years? If so, how?



Erleen Hatfield (Thornton-Tomasetti Group)
(917) 570-6700

February 8, 2006
2 P.M. EST

***STREAMLINING THE STRUCTURAL STEEL DESIGN &
CONSTRUCTION THROUGH COMPUTER MODELING
ARCHITECTS & STRUCTURAL ENGINEERS***

1. How has your development of design drawings changed over the past five years? (3D modeling, etc.)
 - a. Design drawings are now being design models, model is now the contract document. (Referenced in the new AISC Manual)
 - i. Bears, DC Baseball, Geary Project,
 - b. Model is given to contractors to bid.
 - i. Ex. Soldier Field → model given to steel fabricator
 - c. Thornton-Tomasetti often does not design own connections.

2. Do you currently develop a 3D model for your projects? If so what modeling software do you use? Is this model available to the contractor?
 - a. Revit Structure, Tekla, AutoCAD with 3D dimensional objects...
 - i. Advantage: defined scope with BIM, everyone has the same quantities, much better way of deliver

3. As a designer, what are the barriers to implementing 3D modeling/BIM on a project? (cost, time, value, legal, etc.)
 - a. Training
 - b. Different way of thinking
 - c. More information needed early – architect and owner forced to make decisions early
 - d. Tons of legal issues
 - i. Take risk off of using the BIM and reference 2D drawings
 - ii. New code of standard practices
 - e. A lot of the problem is engineering firms understanding 3D design; senior level must overcome
 - f. Definitely a learning curve in the beginning
 - i. Feels much more cost effective in 3D
 - g. Coordination easier
 - h. Sections easier

4. What phase of a project does the steel detailer become involved? Does this ever occur during preconstruction?
 - i. TT has acquired a lot of detailers to work in the office to assist with assisting with design for details and connections.
 - ii. Engineers with a fabrication background

- iii. This is a great resource for TT

- 5. Review Meetings
 - a. Every few weeks go formally through the model internally
 - b. Architects are not drawing in 3D
 - i. Not a problem because there are a lot of misopportunities

- 6. Describe the communication techniques between the designer and detailer during the shop drawing development process.
 - a. Typically, all communication goes through general contractor or construction manager
 - b. Process much faster with given a model
 - i. For soldier field, model was reviewed instead of paper drawings.
 - ii. Shop drawing process went much faster.

- 7. Describe some common problems during the development of shop drawings.
 - a. Biggest problem is architect changing something during approval process.
 - b. Getting architect up to speed with technology and approving in 3D.
 - i. Viewing on a screen versus viewing on a drawing.
 - 1. 21” desktop monitors

- 8. Describe the ideal steel shop drawing review process.
 - a. Not applicable

- 9. If you experience problems exchanging data between applications, do they use CIS/2 files? Do you think the design to construction process will change in the few years? If so, how?
 - a. This is the biggest pain in the neck. Industry isn't there yet.
 - i. CIS/2 is not very helpful.
 - b. Interoperability
 - i. TT writes a lot of the application data interchange in-house
 - ii. Navisworks

- 10. Feels this is a very timely topic and relevant to the industry. TT is on the cutting edge with this information.



Nathan Appleman (HOK Sport)
Kevin Fast (HOK Sport)
(816) 221-1500

February 22, 2006
3 P.M. EST

***STREAMLINING THE STRUCTURAL STEEL DESIGN &
CONSTRUCTION THROUGH COMPUTER MODELING
ARCHITECTS & STRUCTURAL ENGINEERS***

1. How has your development of design drawings changed over the past five years? (3D modeling, etc.)
 - a. Fabricator or designer can design connections.
 - b. Superstructure in a stadium becomes visual and architectural aspect of facility.
 - c. Beaver Stadium project
 - i. 2D drafting for construction documents with a parallel 3D model not ADT 06 BIM.
 - ii. 3D systems weren't integrated
 - iii. Kyle Crawl from TT was able to update framing diagram and give to HOK for visual aesthetics.
 1. Very helpful for architectural purpose.
 - d. Struggle with BIM
 - i. Consultants don't utilize software
 1. Interoperability
 - ii. If they do have ability to use software...
 1. at Colorado State, MEP engineers took BIM and identified problems with MEP vs. structure
 - e. Currently,
 - i. Larger projects will often use BIM more so than smaller projects because often contain larger players.
 - ii. Architects learning how to draw in 3D is often a hassle. (shifting with times)
2. Do you currently develop a 3D model for your projects? If so what modeling software do you use? Is this model available to the contractor?
 - a. Autodesk ADT
 - i. Won't utilize full capabilities of software
 - b. Ideally, model would be available to all project players
 - i. Have not been involved in a project that has done that.
3. As a designer, what are the barriers to implementing 3D modeling/BIM on a project? (cost, time, value, legal, etc.)
 - a. Inefficiencies in carrying a model that far as a structural project manager.



- i. All designer consultants must have the ability to meet all deadlines during design phase.
 - b. Depends if HOK is design architect or full (local) architect
 - i. Depends when the project is turned over (50% DD, SD, etc.)
 - c. More costly to implement BIM only because of learning curve.
 - i. Once project team / design team has overcome the initial learning process.
 - ii. Labor/Fee time for initial less efficiency.
 - iii. Building cost is constantly changing at each design phase.
 1. Budgets at each design phase often don't match owner's cost.
 2. Doesn't pay to get as detailed early during design because of uncertainties in project.
 3. BIM will allow for more accurate estimate but ultimately is it worth it?
4. What phase of a project does the steel detailer become involved? Does this ever occur during preconstruction?
- a. Depends on size of project size/scope
 - b. Qualifications of structural engineer
 - i. Sometimes SE does not provide detailing services
 - ii. Sometimes SE provides as "add" services
 - c. Depends on delivery method of project
 - i. D/B relationship between design team/construction team
 - d. Detailer will add value for less headaches down the road
 - i. Owner will have to determine if this extra cost is worth it.
 - ii. Makes SD, fabrication, and CO process easier.
 1. Not perfect for small projects.
 - iii. Important to understand what services a structural engineer provides.
 1. often just loads, forces, and some detailing.
 2. connection details and specifics by fabricator.
 3. ideally an engineer would provide everything (3 tiers)
5. Describe the communication techniques between the designer and detailer during the shop drawing development process.
- a. See Question #7
6. Describe some common problems during the development of shop drawings.
- a. Biggest problem seen is when design drawings are issued there are often a lot of assumptions and clarifications.



- i. This is meant that contractor has a lot of assumptions and clarifications and this is how steel is procured.
 - ii. Steel structure design is finalized during detailing.
 - iii. This results in design team often rejecting submittals.
 1. what are most recent drawings?
 - b. Experience level of detailer and who is responsible for connection design.
 - c. If contractor doesn't copy all the necessary parties on submittals.
 - d. Design team may not turn submittals around quick enough, may result in delays.
 - e. Re-submittals present a problem and make the process even longer.
7. Describe the ideal steel shop drawing review process.
 - a. First, and foremost, GC/CM must submit a schedule for when shop drawings will arrive and amount of shop drawings.
 - i. When will delivery be needed
 - ii. When will fabrication begin
 - iii. **Clearly show design team what to anticipate
 - iv. ****This will provide a road map for all parties to meet schedule
 - v. Design team will provide feedback to schedule. (SE will also review schedule and recommend changes to schedule, order of shop drawing process)
 - b. CM must review shop drawings and comment on the shop drawings before go to the structural engineer.
 - i. Erection sequence has a lot to do in determining what shop drawings will be developed first.
 - c. Steel shop drawings often will go directly to structural engineer as long as HOK is copied.
 - i. This is due to the fact for the quick turn-around.
 - d. Any dialogue between SE and fabricator, CM must be present and all discussions must be document.
 - e. Architects are obligated by contract for many times a 15 day turn around in getting shop drawings back.
 - i. HOK uses AIR (architect information requests) to fabricator to avoid delay or rejecting shop drawings.
 - f. Verbal conversations are often documented to avoid liability constraints.
 - i. Who said what, etc.
 - g. On a \$25M project, shop drawing submittal length
 - i. Delivery of steel is often within 2 months of contractor award.
8. If you experience problems exchanging data between applications, do they use CIS/2 files? Do you think the design to construction process will change in the few years? If so, how?



-
- a. First step, everyone must agree on a type of software. (will this ever happen?)
 - i. Everyone must utilize a certain system and this will eliminate inefficiencies.
 - b. Change has come really quickly.
 - i. 10 years ago still drawing with pencil.
 - ii. 14 versions of AutoCAD in last few years.
 - iii. Then ADT came out and Revit followed later.
 - c. Software companies must meet needs of industry.
 - i. ADT isn't a good presentation tool.
 - d. Efficiency and competitiveness is a concern for the design team.
 - i. How can they be successful with implementing technology?
 - ii. All in favor of implementing but must be able to compete.
 - e. Everyone must buy into it from the beginning.
 - f. Until it is documented that a BIM lessens change orders by 50%, owner's won't be willing to invest in higher design fees.
 - i. Overall feeling with BIM is that it will lessen change orders but this has not been documented and proven.



SAMPLE INTERVIEW QUESTIONS

STREAMLINING THE STRUCTURAL STEEL DESIGN & CONSTRUCTION THROUGH COMPUTER MODELING STEEL FABRICATORS & STEEL DETAILERS

1. Have the development of shop drawings changed over the past five years? (3D modeling, etc.)
2. When did 3D modeling start to impact the process (if at all)?
3. Do you currently develop a 3D model for your projects? If so what modeling software do you use?
4. Is detailing of steel shop drawings performed in-house or is the contracted to a third party?
5. What phase of a project does the steel detailer become involved? Does this ever occur during the design phase?
6. Describe the communication techniques between the designer and detailer during the shop drawing development process.
7. Describe some common problems during the development of shop drawings.
8. If a structural engineer develops the steel design in 3D will this benefit the detailer? If so, how? Also, are there any problems with an engineer developing the design in 3D?
9. What are the barriers to implementing building information modeling (BIM) on a project? (cost, time, legal, etc.)
10. How has your fabrication process changed over the past five years? (digital fabrication, etc.)
11. Who typically manages the supply-chain between all the different entities associated with the steel phase of a project? Does their role change with BIM?
12. If you experience problems exchanging data between applications, do they use CIS/2 files? Do you think the design to construction process will change in the few years? If so, how?
13. Describe the ideal steel shop drawing review process.



Glenn Sherrill (Steelfab of Alabama)
(704) 394-5376

February 15, 2006
12:30 P.M. EST

***STREAMLINING THE STRUCTURAL STEEL DESIGN &
CONSTRUCTION THROUGH COMPUTER MODELING
STEEL FABRICATORS & STEEL DETAILERS***

1. Have the development of shop drawings changed over the past five years? (3D modeling, etc.)
 - a. Yes, 3D modeling (only 30% in-house)
 - i. X-Steel
 - ii. SDS/2
 - iii. A-Steel
 - b. Once model is created including connections, download CNC and KISS files and then Computer Numerically Control equipment receives information
 - i. A man use to do this, but now all done electronically
 - ii. More accuracy (to 1/16")
 - c. Changes to design documents is still a problem
 - i. Software doesn't handle this easily
 - d. Detailer Input
 - i. When using 3D modeling software, every dimension is needed.
 - ii. Design needs to be fully finished for the 3D steel model to be developed.
2. When did 3D modeling start to impact the process (if at all)?
3. Do you currently develop a 3D model for your projects? If so what modeling software do you use?
 - a. Yes, see question #1.
4. Is detailing of steel shop drawings performed in-house or is the contracted to a third party?
 - a. 70% of detailing subbed contractor
5. What phase of a project does the steel detailer become involved? Does this ever occur during the design phase?
 - a. No, wait until job is awarded.
6. Describe the communication techniques between the designer and detailer during the shop drawing development process.
 - a. Depends on past relationship with engineer.
 - b. Sometimes a conference call is needed with third party.



7. Describe some common problems during the development of shop drawings.
 - a. Time – often greater than 2 weeks for approval
 - i. Makes it tough to keep schedule with unknown approval phase of steel shop drawings
 - b. Contract drawing revisions
 - c. Communication

8. If a structural engineer develops the steel design in 3D will this benefit the detailer? If so, how? Also, are there any problems with an engineer developing the design in 3D?
 - a. Yes this is happening on several projects however the model is not kept up-to-date throughout the project.
 - i. Model data transferred into X-Steel.
 - b. Engineers usually have no problem giving the model or they make a sign-off sheet available.
 - c. Engineer says...
 - i. Here's the model do whatever you want with the model.
 - ii. The drawings still govern true design.

9. What are the barriers to implementing building information modeling (BIM) on a project? (cost, time, legal, etc.)
 - a. See above - question #8
 - b. Controlling contractor must govern the updating of the model and make it mandatory.
 - c. Approximately 20 projects have been given a model during the bid phase and then GMP

10. How has your fabrication process changed over the past five years? (digital fabrication, etc.)
 - a. CNC controlled has been used in the late 80s.

11. Who typically manages the supply-chain between all the different entities associated with the steel phase of a project? Does their role change with BIM?

12. If you experience problems exchanging data between applications, do they use CIS/2 files? Do you think the design to construction process will change in the few years? If so, how?

13. Describe the ideal steel shop drawing review process.

14. Words of Wisdom
 - a. Glad to see this is being studied and this is very useful.



Mark Holland (Paxton & Vierling Steel Co.)
(712) 347-4260

February 24, 2006
3:30 P.M. EST

***STREAMLINING THE STRUCTURAL STEEL DESIGN &
CONSTRUCTION THROUGH COMPUTER MODELING
STEEL FABRICATORS & STEEL DETAILERS***

1. How has your development of design drawings changed over the past five years? (3D modeling, etc.)
 - a. Percentage of people who deliver a 3D model is about 3%.
 - i. Some of the bigger firms deliver a “certified model” and that’s the contract document.
 - b. 3D modeling application generates the shop drawing and the detailer extracts information.
 - i. 40-50% and constantly increasing.
 - c. The constraints for expanding the use of technology is contract and liability based.
 - i. Engineer will “lose” control of design if he gives up his model.
 - ii. Fee based and contract based issues, not modeling.

2. Do you currently develop a 3D model for your projects? If so what modeling software do you use? Is this model available to the contractor?
 - a. Data design SDS/2
 - b. Receive information from Tekla X-Steel
 - c. Have tried to have engineer approve the model instead of printing shop drawings, but it has only happened on several projects.
 - i. These projects were more successful with a better understanding of what all parties wanted.
 - d. Fabricator must model everything in order to correctly build project. Create model in order to get equipment to work.

3. If a structural engineer develops the steel design in 3D will this benefit the detailer? If so, how? Also, are there any problems with an engineer developing the design in 3D?
 - a. Yes this has occurred.
 - b. Depends how accurately the engineer models the project.
 - c. Information must be received in CIS/2 file standard. This is a technical problem.
 - i. This is a market problem that will be solved as demand gets higher.
 - d. Mark is convinced that the interoperability problems will be solved by the software developers. Software developers will feel the demand from market conditions.



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- i. Georgia Tech website
 4. How has your fabrication process changed over the past five years? (digital fabrication, etc.)
 - a. 4 story office structure (400 tons)
 - i. Structural steel detailer: start to finish 5 weeks for model.
 - ii. Raw mill order is 8 weeks.
 - b. Save time by simplifying review process.
 - c. SIM Steel 2 data exchange cd rom by Mark Moser (first of 2 cd's).
 5. As a designer, what are the barriers to implementing 3D modeling/BIM on a project? (cost, time, value, legal, etc.)
 - a. Tradition
 - b. Contract language
 - c. Fee issues
 6. What phase of a project does the steel detailer become involved? Does this ever occur during preconstruction?
 7. Describe the communication techniques between the designer and detailer during the shop drawing development process.
 - a. Through a GC and makes process more of a hassle.
 - b. Attach screen shot of model to questions.
 8. Describe some common problems during the development of shop drawings.
 - a. Incomplete design documents mostly due from owner not making decisions.
 - b. Changes to design.
 9. Describe the ideal steel shop drawing review process.
 - a. Engineer gives a certified model or a model done in an application that generates a finished model.
 - i. With loads
 - b. Contract that states "Mark you can move members around."
 - c. Only drawings to see would be erection drawings.
 10. If you experience problems exchanging data between applications, do they use CIS/2 files? Do you think the design to construction process will change in the few years? If so, how?
 11. Words of Wisdom
 - a. Review AISC Code of Standards Appendix A

- b. Within 5 years, this will be a new project delivery system. Don't get wrapped up in the contractual issues and focus on the added value that can come of modeling.



Babette Freund (Ritner Steel)
(717) 249-1449

March 7, 2006
12:30 P.M. EST

***STREAMLINING THE STRUCTURAL STEEL DESIGN &
CONSTRUCTION THROUGH COMPUTER MODELING
STEEL FABRICATORS & STEEL DETAILERS***

1. Have the development of shop drawings changed over the past five years? (3D modeling, etc.)
 - a. Yes - from hand drawing to computer automation.
2. When did 3D modeling start to impact the process (if at all)?
 - a. Past couple of years.
3. Do you currently develop a 3D model for your projects? If so what modeling software do you use?
 - a. Yes – SDS/2
4. Is detailing of steel shop drawings performed in-house or is the contracted to a third party?
 - a. Yes – depends on size, complexity, work load, schedule.
5. What phase of a project does the steel detailer become involved? Does this ever occur during the design phase?
 - a. Yes - rarely occurs during design; mostly after award.
6. Describe the communication techniques between the designer and detailer during the shop drawing development process.
 - a. Not enough – constant communication with designer is needed.
7. Describe some common problems during the development of shop drawings.
 - a. Better design meaning design what can be built.
8. If a structural engineer develops the steel design in 3D will this benefit the detailer? If so, how? Also, are there any problems with an engineer developing the design in 3D?
 - a. Not if it isn't accurate.
9. What are the barriers to implementing building information modeling (BIM) on a project? (cost, time, legal, etc.)
 - a. Legal – CIS/2 has helped with this issue.
 - b. Accountability
 - c. Ownership



-
-
- d. Accuracy
 - e. It is important to develop a good working relationship with the engineering firm in order to implement this technology.
10. How has your fabrication process changed over the past five years? (digital fabrication, etc.)
- a. Software.
11. Who typically manages the supply-chain between all the different entities associated with the steel phase of a project? Does their role change with BIM?
12. If you experience problems exchanging data between applications, do they use CIS/2 files? Do you think the design to construction process will change in the few years? If so, how?
13. Describe the ideal steel shop drawing review process.
- a. No RFI's.
 - b. Better standardize the design.



SAMPLE INTERVIEW QUESTIONS

***STREAMLINING THE STRUCTURAL STEEL DESIGN &
CONSTRUCTION THROUGH COMPUTER MODELING
CONSTRUCTION MANAGERS***

1. Have the development of shop drawings changed over the past five years? (3D modeling, etc.)
2. Has 3D modeling / building information modeling (BIM) changed the steel shop drawing development and review process? If so, how?
3. If you receive a BIM from a designer, how is the model used? (conflict resolution, estimating, tracking fabrication, digital fabrication, construction visualization, coordination, etc.)
4. What phase of a project does the steel detailer become involved? Does this ever occur during the design phase?
5. Describe the communication techniques between the designer and detailer during the shop drawing development process.
6. Describe some common problems during the development of shop drawings.
7. Who typically manages the supply-chain between all the different entities associated with the steel phase of a project? Does their role change with building information modeling?
8. If you experience problems exchanging data between applications, do they use CIS/2 files? Do you think the design to construction process will change in the few years? If so, how?
9. Describe the ideal steel shop drawing review process.



Ryan Maibach (Barton Malow Company)
(734) 732-0934

February 9, 2006
8:30 A.M. EST

***STREAMLINING THE STRUCTURAL STEEL DESIGN &
CONSTRUCTION THROUGH COMPUTER MODELING
CONSTRUCTION MANAGERS***

1. Have the development of shop drawings changed over the past five years? (3D modeling, etc.)
 - a. Try and contact Tim Webster...
 - b. Definitely has changed, but also depends on size of project.
 - i. Steel drawings done by hand five years ago.
 - ii. Recently, drawings developed in 3D, but the 3D model was not given to A/E.
2. Has 3D modeling / building information modeling (BIM) changed the steel shop drawing development and review process? If so, how?
3. If you receive a BIM from a designer, how is the model used? (conflict resolution, estimating, tracking fabrication, digital fabrication, construction visualization, coordination, etc.)
 - a. Not really sure, need to understand intent from engineer. Will the model be used for other systems (MEP)? What exactly can the model be used for?
4. What phase of a project does the steel detailer become involved? Does this ever occur during the design phase?
 - a. Fabricator detailer has not been involved during design. Ryan has been mostly involved with laboratory / healthcare work.
5. Describe the communication techniques between the designer and detailer during the shop drawing development process.
 - a. Often depends on willingness of designer. Detailer often prefers this, but often this is not the case.
 - b. Will the owner see this as value added.
6. Describe some common problems during the development of shop drawings.
 - a. Biggest challenge is the ability of designer or detailer; process just takes time.
7. Who typically manages the supply-chain between all the different entities associated with the steel phase of a project? Does their role change with building information modeling?



-
- a. Awarded to one company and then their job to subcontract to necessary companies.
8. If you experience problems exchanging data between applications, do they use CIS/2 files? Do you think the design to construction process will change in the few years? If so, how?
 - a. True driver is the median. So many players and participants. Challenge is time frame.
 9. Describe the ideal steel shop drawing review process.
 10. Words of Wisdom
 - a. Find a median engineer and get their take. Try and understand where that type of company is headed.
 - b. Few other people to try and talk to...
 - iii. Tim Webster – Barton Malow
 - iv. Neil Lennon?? – Barton Malow (GM Projects)
 - c. Don't necessarily limit the model to steel
 - v. BIM will be a huge tool for the MEP process.



Ron Sinopoli (Barton Malow Company)
(434) 455-2447

March 10, 2006
11:00 A.M. EST

***STREAMLINING THE STRUCTURAL STEEL DESIGN &
CONSTRUCTION THROUGH COMPUTER MODELING
CONSTRUCTION MANAGERS***

1. Have the development of shop drawings changed over the past five years? (3D modeling, etc.)
 - a. Yes, we were doing it 4 years ago on the Soldier Field Project. Since then the technology and the industry have become more familiar with the process as standards are being implemented (see AISC Code of Standard Practice) thus developing new and quicker ways to exchange information.
 - b. Is it really quicker?
 - i. Typically have to stamp and mark-up 6 sets of shop drawings. On soldier field, model exchange through TT. Only certain number of drawings printed for stamped approval. CM saving 8-16 MH.

2. Has 3D modeling / building information modeling (BIM) changed the steel shop drawing development and review process? If so, how?
 - a. Absolutely. With the steel detailers using 3D models to develop fabrication models that are linked to Fabtrol and Ravens the ability to get the model “approved” and not process large sums of shop drawings is a huge time savings. The use of “3D Models” also helps with jobs that have complicated geometry.
 - i. Not as many drawings needed to print-out.

3. If you receive a BIM from a designer, how is the model used? (conflict resolution, estimating, tracking fabrication, digital fabrication, construction visualization, coordination, etc.)
 - a. Unfortunately I have not had the opportunity to get a full “BIM” model from a designer. At Soldier Field we got a “3D Steel Model” developed in Tekla’s Program “X Steel” for use in developing shop drawings and connection design. A full BIM Model will help with all of the above mentioned, however estimating would be the lowest on the list in my opinion.
 - i. If estimating is in quantity take-off, then yes BIM modeling would help.
 - ii. Helps with scope reviews.

4. What phase of a project does the steel detailer become involved? Does this ever occur during the design phase?



- a. Usually after the Steel Fabricators Contract is awarded, unless the project is a design build or includes a design assist.
5. Describe the communication techniques between the designer and detailer during the shop drawing development process.
 - a. Currently it is through the RFI process.
 - i. More or Less RFIs with model?
 1. Not necessarily more/less RFIs, just when the RFIs are generated.
 6. Describe some common problems during the development of shop drawings.
 - a. Geometry.
 - b. Coordination with the Architectural Plans and MEP System Openings.
 - c. Fully developed load analysis completed by the structural engineer to allow connection design to begin immediately.
 7. Who typically manages the supply-chain between all the different entities associated with the steel phase of a project? Does their role change with building information modeling?
 - a. The Construction Manager.
 - b. The role should not change if a BIM Model is used, it only gets easier and allows better coordination.
 8. If you experience problems exchanging data between applications, do they use CIS/2 files? Do you think the design to construction process will change in the few years? If so, how?
 - a. No “problems per say” however, it’s how the file is inserted that is the issue. The coordination of insertion points, north arrow and elevations are extremely important. All subcontractors that will work in the BIM environment must be given a set of standards to hold.
 - b. Also when importing/exporting files the program used by the sub does not always export as a “solid” into the base program used by the CM. This is currently being worked thru within the industry.
 - i. Ron currently uses Tekla Structures. BM also uses Navisworks, Graphisoft, etc. Link ProLog, Primavera, etc. to Tekla Structure. Get a clipping plane, etc. Need a program that’s dumped in as a solid which is currently something that’s going with Tekla Structure.
 - ii. Tekla is trying to make their program compatible with all other programs. Need a program that will bring all information together.
 - iii. Need to be used as a construction tool. How does it benefit all involved?



1. Allows for RFIs to be better recognized, what changes affect who, show this better to owner through model.
9. Describe the ideal steel shop drawing review process.
- Please note the process below is based upon a phased release of documents currently used on this job (early utilities, structure, Architectural/MEP). The process would be a great deal more complicated if all trades are working simultaneously in terms of phasing and coordination developed by the CM to best serve the job.
- a. Designer issues a BIM Model for the Major Trades, this model should be used for “Space Reservation” only. I.E. does not need to be extremely detailed in regards to how the MEP equipment is shown ect.....:
 - i. Steel
 - ii. Concrete (rebar does not need to be included)
 - iii. Skin (Masonry is Optional)
 - iv. MEP Systems
 - v. Precast
 - b. The CM accepts the Model from the A/E and posts it to an FTP site for use by the trades. This should be a “For Construction Model”. There are two ways to do this:
 - i. The CM breaks the model into it’s components for use by the trade required.
 - ii. The model is left in it’s original state to be accessed and imported/exported by the subs.
 - c. Subs begin the shop drawing process
 - d. Subs electronically submit the shop drawing model for approval. The model is:
 - i. Posted to the FTP site:
 1. In it’s original state for review by the A/E and CM
 2. Inserted back into the master model for re-verification of coordination and clash check. Thus beginning and “As-Built Model” that can be used for coordination for follow on trades detailing.
 - e. The A/E review and provide comments in regards to design intent. The comments are in narrative form and by sketch, or comments inserted into the model, whichever is easiest to accomplish.
 - f. The CM review and provide comments in regards to coordination with other trades and sequencing.
 - g. Model with an action (APP, APN, R&R Ect.) from A/E is posted back to the FTP site for download by all involved.
 - h. Subcontractor incorporates comments from A/E into approved model as “Final Field/Fabrication” and re-posts to FTP Site for incorporation into

the “Master Model”. 2D document would be needed at this point for field use.

10. Other Relevant Information

- a. E&O Insurance should go down with engineers implementing modeling.
- b. All based on delivery system and phasing of document risk.
 - i. At VA, did not receive 3D file from architect.
- c. Agrees with a better understanding of design in eyes of design team if the project is modeled in 3D, etc.
 - i. Better QC from a designer’s perspective.