THE ROAD TO PRODUCTIVITY

Lessons Learned by the Structural Steel Industry

Tom Faraone, PE
Senior Regional Engineer
October 31, 2006
It started with the mills...

1980

12 man-hours/ton

PRODUCTIVITY

Today

.5 man-hours/ton

1/3 the energy

40% higher strength

37% reduction in GHG

Lessons Learned from the Structural Steel Industry
PRODUCING MILL

Wide Flange, Plate, Coil, Strip

HSS PRODUCER

SERVICE CENTERS

FABRICATOR

Detailer, Erector

JOIST MFG

PROJECT

20% to 40% of steel package cost

60% to 80% of steel package cost

Lessons Learned from the Structural Steel Industry
A BIM Roadmap

Detailing

Material Handling and Identification

Cutting and Drilling

Delivery and Erection

Painting (if required)

Fit Up

Lessons Learned from the Structural Steel Industry
STRUCTURAL FRAMING SYSTEM

- Structural Design
- 3D Modeling & Detailing
- Material Orders and Scheduling
- Fabrication

Lessons Learned from the Structural Steel Industry
A BIM Roadmap

STRUCTURAL FRAMING SYSTEM

Structural Design

3D Modeling & Detailing

Material Orders and Scheduling

Fabrication

Lessons Learned from the Structural Steel Industry
A BIM Roadmap

Engineer

Analysis Application

Export

Translators

Detailing Application

Import

CIS/2 Data Exchange File

Fabricator

Lessons Learned from the Structural Steel Industry
CIS/2 Structural Steel Product Model (Building Model)

CIS/2 integrates all information needed for design, analysis, procurement, fabrication planning, fabrication automation and logistics and erection of structural steel in buildings.
Casino of the Sun, Tucson, AZ

425 tons

Fabrication Started 3/14
Erection Begun 3/26
Topped Out 4/11

Lessons Learned from the Structural Steel Industry
Glenn Oaks Schools, Queens, NY
3500 tons

• Significantly reduced detailing errors
• Reduce review time for shop drawings
• Increased engineer confidence that what was designed was what was built
• Significant schedule reduction
Baptist West Hospital, Knoxville, TN

Traditional Schedule 18 weeks
Actual Schedule 11 weeks
Time Saved 7 weeks

Lessons Learned from the Structural Steel Industry
Soldier Field, Chicago, IL

One Season!

Lessons Learned from the Structural Steel Industry
Mt Tahoma High School, Tacoma, WA

1900 TONS

Saved 3 months

Only 13 RFIs on 3,035 assemblies

Only 4 of 15,256 bolts not aligned

Lessons Learned from the Structural Steel Industry
Lansing Community College

Saved $2.35/SF
(8% of steel package)

Lessons Learned from the Structural Steel Industry
Why not more?

Structural Engineers

Owners

Detailers

Fabricators

Lessons Learned from the Structural Steel Industry
RESISTANCES:
Additional Cost
Model Discipline
Level of Model Detail
Release of Proprietary Information
Model Ownership
Dimensional Definitions
2-D Drawings Required for Permitting
Acceptance as Contract Documents
Contractual Relationship Definitions
Model Quality
Design-Bid-Build Process
Staffing Responsibilities
Multiple Software Platforms
I Don’t Want to be First
Code of Standard Practice for Steel Buildings and Bridges

March 18, 2005

Supersedes the March 7, 2000 AISC Code of Standard Practice for Steel Buildings and Bridges and all previous versions.

Prepared by the American Institute of Steel Construction, Inc. under the direction of the AISC Committee on the Code of Standard Practice and issued by the AISC Board of Directors.

DIGITAL BUILDING PRODUCT MODELS

This Appendix shall apply when the contract documents indicate that a digital building product model replaces contract drawings and is to be any means of designing, representing, and exchanging structural steel data. When this is the case, all references to the Design Drawings in this Appendix apply to the Design Model, and all references to the Shop Drawings in the Code shall instead apply to the Manufacturing Model. The Design Model shall be used as the building product model for structural steel.

Glossary

3D: A digital information structure of the objects making up a product, function, behavior and relations of the parts and within one or more building systems. A building product model can be created in multiple ways, including as an ASCII file or as a database. The data is entered, manipulated, evaluated, reviewed and presented using design, engineering, and manufacturing applications. Traditional methods for designing and specifying buildings are undergoing a digital transformation. Traditional paper documents are being replaced by digital product models.

CIS2: (Computer Integrated Construction Software) A standard for the exchange of information between design and construction software applications.

EDO: (Electronic Data Interchange) The specification providing the standard technical data for steel and concrete structural drawings required for electronic electronic exchange.

EPM: (Electrical Product Model) A standard for the exchange of electrical design information between design and construction software applications.

Lessons Learned from the Structural Steel Industry
THE STEEL TEAM

Structural Engineer  Detailer  Erector

Mill  Service Center  Fabricator

Lessons Learned from the Structural Steel Industry
THE STEEL TEAM

Architect

HVAC

Structural Engineer

Detailer

Erector

Mill

Service Center

Fabricator

THE PROJECT TEAM

Electrical

General

Other Specialty

Plumbing

Lessons Learned from the Structural Steel Industry
STRUCTURAL FRAMING SYSTEM

Structural Design

3D Modeling & Detailing

Material Orders and Scheduling

Fabrication

Lessons Learned from the Structural Steel Industry
Design-Build

$2.345 Million

$16.28/SF

772 tons

$3037.57/ton

Design-Bid-Build

$2.8 Million

$19.44/SF

910 tons

$3078.82/ton

A BIM Roadmap

As partners in the Design-Build (DB) delivery of the structural and steel component of this project, Ruby + Associates worked closely with Art Iron (Toledo, OH) to design and construct this four-story, 144,000 square foot facility for the St. Vincent Mercy medical campus. Using Constructability concepts and the DB delivery method, the structural project team compressed the steel schedule for the project, expediting an aggressive project completion target.

Art Iron and Ruby adopted electronic document sharing to seamlessly join the steel design and fabrication elements of the project. Ruby performed the engineering analyses and created the structural model that guided the steel fabrication. Art Iron provided input into the model and design throughout the process. Many economies were designed into the structure throughout this initial collaboration. When the model was completed, Ruby sent the files electronically to Art Iron, an Advance Bid of Materials for ordering raw steel was generated, and shop drawings were created. The review process was also performed electronically. The schedule was significantly reduced by using the design model to create the 3D detailing model. This approach facilitated “real-time” collaboration on the structural design and shop fabrication drawing development.

Design-Build Method

| Design Time | 10 weeks |
| Bit / Estimate Time | 5 weeks |
| Award Time | 0 weeks |
| Prepare ABM (1) day |
| Order Material (1) week |
| Detail Shop Drawings (6) weeks |
| Approval Review Time (1) week |
| Incorporate Design Changes (1) week |
| Fabricate Steel (6) weeks |
| Erect Steel (6) weeks |
| Total Duration | 36 weeks & 1 day |
| Real Time Schedule Savings | 17 weeks |

Dollars & Sense:

$2,345,000.00
$16.28 / SF
772 Tons
$3037.57 / Ton

Lessons Learned from the Structural Steel Industry
FOTA
First Organize, then Automate
And then came BIM...
And then came BIM…

Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry

<table>
<thead>
<tr>
<th>Stakeholder Group</th>
<th>Planning, Engineering, Design Phase</th>
<th>Construction Phase</th>
<th>O&amp;M Phase</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Architects and Engineers</td>
<td>$1,807.2</td>
<td>$147.0</td>
<td>$15.7</td>
<td>$1,169.8</td>
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<tr>
<td>General Contractors</td>
<td>485.9</td>
<td>1,265.3</td>
<td>30.4</td>
<td>1,801.6</td>
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<tr>
<td>Specialty Contractors/Suppliers</td>
<td>442.4</td>
<td>1,762.2</td>
<td>---</td>
<td>2,204.6</td>
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<tr>
<td>Owners and Operators</td>
<td>722.8</td>
<td>898.0</td>
<td>9,077.2</td>
<td>10,648.0</td>
</tr>
<tr>
<td>All Stakeholders (Total)</td>
<td>2,658.3</td>
<td>4,072.4</td>
<td>9,093.3</td>
<td>15,824.0</td>
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</tbody>
</table>

Source: Table 6.3 NIST
Note: Includes commercial, institutional, and industrial buildings totaling 1.1 billion sq. ft. in “net” and 30 billion sq. ft. in “net in place” construction.

Construction & Non-Farm Labor Productivity Index (1964-2005)

Constant $ of contracts/wages of hourly workers
Sources: U.S. Dept. of Commerce, Bureau of Labor Statistics

Index

Construction Productivity Index (1964 = 100%)
Non-Farm Productivity Index (1994 = 100%)
Building Information Modeling horizontally integrates all building systems into a single, consistent design model allowing coordination of components and elimination of interferences.
The structural steel industry has taken the lead in vertically integrating the design and fabrication process for structural steel through interoperable programs utilizing the CIS/2 protocol.
Building Information Modeling information integrates directly with the vertical structural steel process allowing significant productivity increases by combining the advantages of both horizontal and vertical integration within the context of off-site fabrication.
INCREASED PRODUCTIVITY EQUALS

Greater Value
Lower Costs
Accelerated Schedules
Safer Construction
Application of Lean Construction Best Practices
General Motors
Flint, Michigan

Lessons Learned from the Structural Steel Industry
Denver Art Museum

“…brought in on time and on budget”

“…no claims pending or expected”

BUILDING INFORMATION MODELING:

“…prevented 1,200 collisions of steel elements”

“…sped steel erection to the finish line three months early”

“…gave nearly $400,000 back to the owner”
Wayne L Morse U.S. Courthouse
Eugene, OR

“Fastest GSA project ever.”
“Change orders were less than 3%.”
New Jersey Devils Arena
Newark, NJ

Design Assist:
CD’s completed Dec 16, 2005
Steel erection began March 3, 2006
Hearst Tower
New York, NY

Steel fabricator
shared model with
curtain wall
contractor
Renaissance Boston Waterfront Hotel

Lessons Learned from the Structural Steel Industry
Why not more?

Designers

Owners

Specialty Contractors

General Contractors

Lessons Learned from the Structural Steel Industry
RESISTANCES:
- Additional Cost
- Model Discipline
- Level of Model Detail
- Release of Proprietary Information
- Model Ownership
- Dimensional Definitions
- 2-D Drawings Required for Permitting
- Acceptance as Contract Documents
- Contractual Relationship Definitions
- Model Quality
- Design-Bid-Build Process
- Staffing Responsibilities
- Multiple Software Platforms
- I Don’t Want to be First

Lessons Learned from the Structural Steel Industry
DRIVERS:
Focus on Process more than Software (FOTA)
Document Successes
Develop Appropriate Contractual Language
Redefine “Code of Standard Practice”
Address Objections with Relevant Software
Assign Model Ownership and Responsibility
Focus on the End Result for the Project Owner
Define the Benefits for the Virtual Project Team
Reassess Project Compensation
Encourage Owners to Drive the Process

RECOGNIZE BIM IS NOT ANOTHER FAD!
FOCUS ON PRODUCTIVITY!
We’re not just in the steel business...

We’re in the productivity business!

Lessons Learned from the Structural Steel Industry