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Empowering Structural Engineers: Automating Constructibility Checks During Design

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Learning Objectives

- Explore most common steel issues that engineers face
- Identify how constructability reviews are incorporated into the structural analysis and BIM modeling process
- Visualize new Revit capabilities for performing QA review of the steel frame

Description

This session explores how structural engineers visualize, coordinate and resolve constructability issues early in design by using Qnect for Revit. We will show how Qnect for Revit helps young structural engineers develop a holistic understanding of how a building is put together, enhancing their awareness of interdisciplinary coordination, constructability, erectability and 3D modeling best practices. We will look at the broader benefits of integrating automated constructability checks within the BIM workflow for all project stakeholders across the entire project lifecycle. Business Leaders of engineering firms looking to attract and retain top talent of young structural engineers will want to attend this presentation.

Speaker(s)

VP of Strategy and Business Development, QNECT LLC

Michael is a seasoned business strategist in the AEC tech sector with a focus on structural engineering and fabrication. He practiced as a structural engineer at Ellerbe Becket, holds an MS in Civil Engineering, an MBA from Michael J. Coles College of Business and is a Professional Engineer from California. He is also certified in AI for Business Managers from MIT. He has led strategy leadership positions at Trimble Tekla, Autodesk and Qnect.

Most Common Steel Issues Facing Structural Engineers

The most common issues facing engineers come up due to coordination issues not identified before the design is complete. Steel is ordered early using designs that will eventually change and are not fully coordinated. This includes inaccurate or missing information, coordination issues with other disciplines and aspects of constructability not thought through. Going further, most engineers do not think about steel connection aspects in their designs. They typically leave connection issues up to the fabricators to figure out. Even for engineers that design their connections, many use tables or charts that do not represent the exact situation for every connection instance. Without doing Level of Development 350 modeling of the frame and connections, RFIs will still result.

Trends impacting Steel Coordination Issues (i.e., RFIs)

There are several trends impacting the rise of Request for Information (RFIs) related to steel designs.

Delegated Design is on the Rise

Delegating design without properly defining design requirements leads to problems in the construction phase. In fact, the AISC has defined more stringent language in the latest US Code of Standard Practice to address this growing problem. It guides engineers for how to better document complexity areas in their structural designs, like special reinforcements of the framing like doublers and stiffeners which are due to the steel connection design and load paths. Many engineers are not documenting these details on their engineering drawings which leads to RFIs.

More Complexity & Less Time

Engineers have less time to develop their designs to procure materials early meet projects schedules. Expanding design requirements, geometric challenges, the growing mix of renovation with new construction and fast track projects are exasperating the complexity to coordinate all information in time. This leads to RFIs that must be generated after the subcontractors have been contracted, leading to extensive RFIs.

Optimizing cost, carbon and constructability is a challenge

New design constraints to reduce embodied carbon will challenge engineers to rethink existing practices of “rationalizing” designs with lots of repetition to simplify fabrication and erection. Doing so may conflict with project goals to reduce carbon. New methods of multi-objective trade off analysis will be needed in how engineers design holistically.

Regional Best Practices attempt to improve Steel Coordination

Industry practices vary around the globe to address these gaps in steel coordination between design and construction. In Europe many engineers do the steel detailing as part the structural design so the QA process is internal. However, in other parts like Japan, the UK and France, the connections are delegated similar to the US. Existing guidelines in these countries outline best practices to ensure structural designs are well documented. Below are a list of such resources to reference:

UK:

National Structural Steelwork Specification for Building Construction
In the UK, the NSSS provides coordination checklists for engineers and fabricators:
https://irp.cdn-website.com/de2c1bc5/files/uploaded/NSSS%20Rev06%20CE%20Marking.pdf

Allocation of Design Responsibilities in Constructional Steelwork
Allocation of Design Responsibility Steelwork | PDF | BCSA

France:

CTICM

France CTICM design coordination guidelines provided here:
Monitoring regulatory and normative developments | Steel Construction | CTICM

ISO-17607

France also follows international standard ISO 17607
https://www.iso.org/standard/77280.html

Japan:

These documents provide guidance for quality of fabrication in Japan.

Japanese Architectural Standard Specification (JASS 6). Structural Steelwork Specification for Building Construction
Japan has similar workflows in which engineers delegate connection designs to fabricators. Guidelines suggest design best practices to ensure good constructability.
https://www.aij.or.jp/books/productId/613386/

Technical Recommendations for Steel Construction and Buildings – This document is divided into two parts: Factory Fabrication and On-Site Construction. These guidelines set various standards focusing mainly on quality control related to steel structures, and they are intended more for fabricators than designers.
https://www.aij.or.jp/books/all/productId/613388/ https://www.aij.or.jp/books/all/productId/613389/

USA:

CASE 962D Checklist
Best practices guideline for structural engineers to provide quality construction documents including QAQC checklist.
CASE 962-D (acec.org) (free for CASE members)

AISC Steel Detailing guidelines
Best practices for steel detailers to ensure constructability for fabrication/erection

https://www.aisc.org/publications/detailing-resources2/

AISC Code of Standard Practice

The COSP outlines how engineers should document complex framing joints that require special reinforcement due to the connection design. This includes both moment joints and shear joints.

Code of Standard Practice for Steel Buildings and Bridges (aisc.org)

16.3-20 DESIGN DOCUMENTS AND SPECIFICATIONS

(2) At locations of *connections*, the following requirements shall apply to column stiffeners, web doubler plates, beam bearing stiffeners, and all other member reinforcement required to satisfy strength and equilibrium of forces through the *connection*:

(a) These items, if required, shall be designed by the *ODRD* and shown in the structural *design documents* so that the quantity, detailing, and fabrication requirements can be readily understood, or

(b) Where *connections* and member reinforcement are specified to be designed by a licensed *engineer* working for the *fabricator*, the *ODRD* shall provide project-specific schematic details for member reinforcement with sufficient information for a *fabricator* to obtain an accurate bidding quantity and any limitations regarding the type and connection of member reinforcement. If no quantities or conceptual configurations are shown, member reinforcement at *connections* will not be included in the bid.

Commentary:

When considering member reinforcement, Option 3 is most useful when the *ODRD* delegates the *connection* design, but has selected members to eliminate or minimize the need for member reinforcement at *connections*. Alternatively, the *design documents* should specify that the determination and design of member reinforcement at *connections* is delegated to the licensed *engineer* working for the *fabricator*. In such cases, the *ODRD* is required to provide schematic details for member reinforcement with sufficient information for bidding.

When no quantities and details are shown for column stiffeners, web doubler plates, beam bearing stiffeners, and/or other member reinforcement required to satisfy strength and equilibrium of forces through *connections*, the *fabricator's* bid reflects no *allowance* for these items. Should it subsequently be determined that member reinforcement at *connections* is required, the provisions of Sections 9.4 and 9.5 then apply.

Chapter 16.3 of AISC COSP

Types of QC for Structural Design

Current best practices for ensuring design QC includes disparate solutions used by engineers. Some checks done in structural analysis tools while rest done in Revit or 2D documentation.

Structural Analysis

Industry practices vary around the globe. Some structural analysis tools do checks for framing from connection design but not all. Regions like the UK and Japan are similar to the US where design is delegated and engineers need to think about these areas of complexity even if they don't do the connection design themselves.

Other QC checks important to the structural engineer are verifying that load paths have been thought through and the assumptions around connection types and stiffnesses that inform the behavior in the structural analysis model. Most structural analysis tools accommodate such customization but it is up to the engineers to make the right judgment and assumptions for the modeling of behavior.

QC of Documentation

Coordination between structural analysis and documentation requires tight coordination especially if models aren't in synch. Updates to data like cambering, shear connectors and end forces may not be transferred. Using back checked 2D pdfs to ensure "redlines are picked up".

QC of Multi-Discipline Coordination

This includes checks for coordination like edge of slab with the building envelope. Mechanical openings around elevators or penetrations. MEP coordination through steel web penetrations, Concrete wall brick ledge elevations with civil engineering.

QC of Constructability Impact on Engineering

Examples of constructability checks that impact framing or engineering. This includes steel member reinforcement areas or overly complex connections. Example of a plate girder that is too shallow with wide flanges. Therefore, use a W-shape "chord" member to make more cost-effective.

Examples of Best Practices

Over the past few decades, key industry leaders in the structural steel industry have documented design best practices to ensure good constructability. These insights have been documented online through webinars, articles and roadshows. Below are a few key resources for US structural engineers to review to learn about common best practices in steel construction:

"Field Fixes – Common Problems in Design, Fabrication and Erection: Solutions and Prevention." Jim Fischer (CSD) & Larry Kloiber (LeJeune Steel), AISC roadshow 2006
[Field Fixes: Common Problems in Design, Fabrication and Erection - Solutions and Prevention [N9] (aisc.org)]

98 Tips for Designing Structural Steel, Michael West & James Fischer, Computerized Structural Design, 2018
https://www.aisc.org/globalassets/modern-steel/archives/2010/09/2010v09_98_tips.pdf

Tips for Designing constructable Steel-Framed buildings
Clifford W. Schwinger, PE, March 2011, Modern Steel Construction
https://www.aisc.org/globalassets/modern-steel/archives/2011/03/2011v03_tips_for_design.pdf

STEEL CONSTRUCTABILITY CONSIDERATIONS Expectations vs Reality
SEAC/RMSCA Steel Liaison Committee , September 2019, Section 2.8.5.
https://www.seacolorado.org/docs/Constructability_Considerations_Expectations_vs_Reality.pdf

Constructability of Structural Steel Buildings, AISC Design Guide 23, 2010
Design Guide 23: Constructability of Structural Steel Buildings (Print) | American Institute of Steel Construction (aisc.org)