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Learning Objectives

After viewing this presentation you will know…

1. **How steel joist design improves BIM project development:** Proven advantages and benefits to steel construction.

2. **How BIM supports steel joist design:** key benefits and two methods of adoption – Partial BIM, Full BIM

3. **BIM process management steps:** Joist Kickoff Meeting, Ongoing Coordination Meetings, Pre-Construction Meetings.

4. **Collaboration and interoperability:** Proven outcomes and higher expectations for BIM-based steel joist project design.

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The learning objectives of this course are shown here. The central intent of the course is to identify the cost and performance benefits of integrating steel joists into the building information model (BIM) for a building project.

Learning Objective #1

1. **How steel joist design improves BIM project development:**

   Proven advantages and benefits to steel construction.

1. How joist design improves the BIM project

- A better model – more detail (web system)
- Deeper management of building data
  - Sharing Information
  - Data queries
  - Material summaries

An early advantage of having the steel joists in a BIM model is that the model will provide much more detail to the structural design.

Serving as a reference guide, the model provides actual dimensions and connections for the steel web system of each joist. This added information enables deeper management of the building data. Information can readily be shared. Data queries can rapidly support questions and design decisions. Material summaries are much more detailed and accurate.

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1. How joist design improves the BIM project

- Collaboration
- Another trade joining the team to create a better building design
- Better Coordination
- Forming partnerships
- Process of eliminating uncertainties during construction

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Steel joist design collaboration is optimized using BIM. The joist supplier becomes a member of the team, providing help to create a better building design. An example would be the joist detailer coordinating connections with the steel detailer through an in-model review. The strengthened communication accelerates project design, while minimizing errors that would otherwise be passed to the erection phase.

The increased level of detail eliminates many uncertainties during construction. These advantages can lead to improved schedules and a range of cost reductions.

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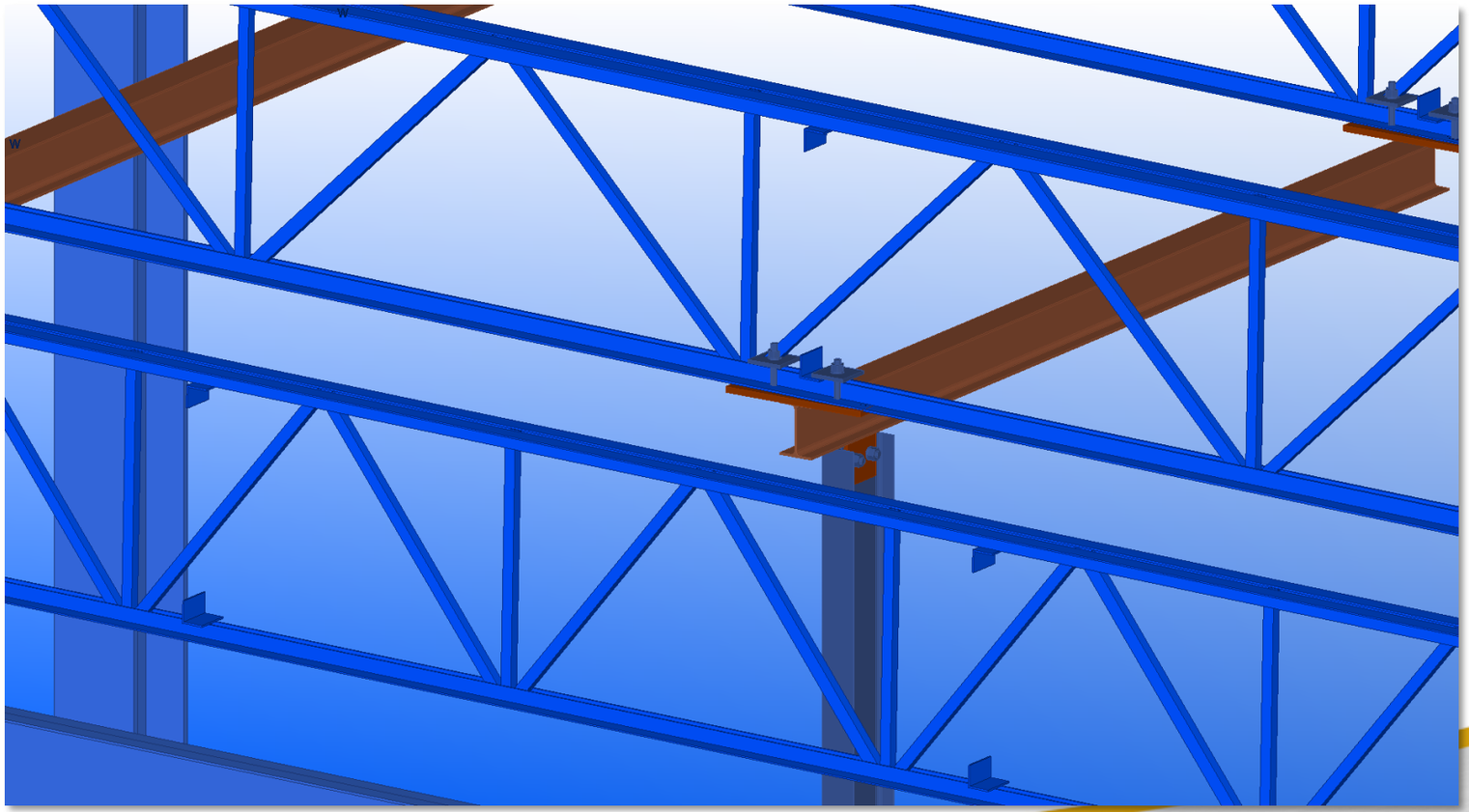
1. How joist design improves the BIM project

- Fewer RFIs
- Better upfront communication
- Prevention of possible back charges
- Improved/efficient designs



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A long-term impediment to project design and development has been the Request for Information (RFI) process. When supported by a BIM joist model, the RFI process is expedited. Points of discussion regarding building components are given immediate clarity within the model, and a proactive joist manufacturer can recommend better solutions in the design of the building. This removes guesswork and costs, as experienced engineers now have a more efficient means for steel joist system design analysis and cost/performance improvement.

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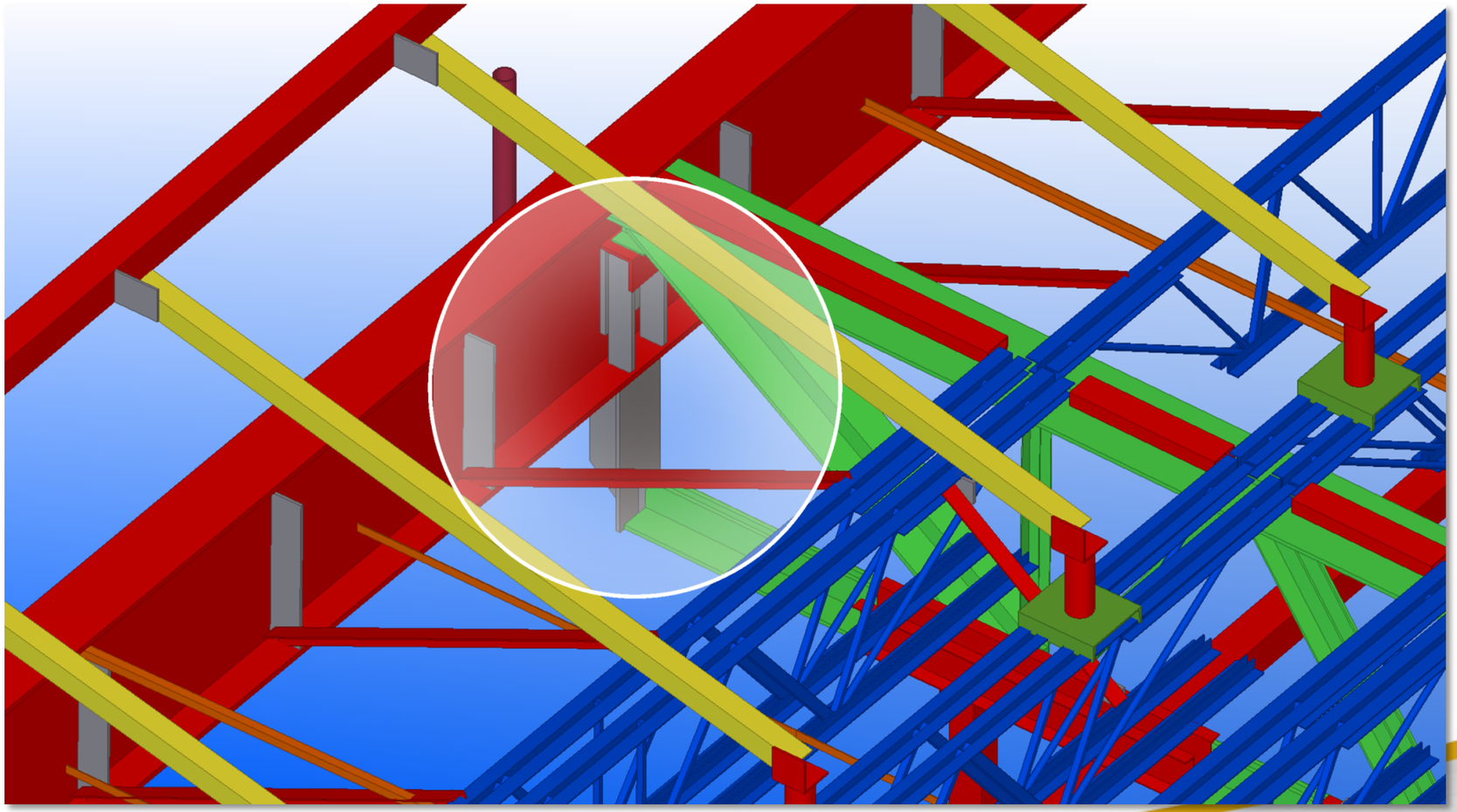
1. How joist design improves the BIM project



The highly visual guidance of a BIM model is often a cost preventer. In this actual steel joist project example, the design engineer requested a bottom chord extension on this girder. The extension was provided by the joist company in the BIM model. However, during a subsequent BIM review by the steel detailer, the detailer discovered a missing stabilizer plate for the bottom chord extension. The detailer had simply overlooked placing this in the design. So they added a special stabilizer to catch the girder extension. This was a no/low cost fix in the BIM project. But it would have led to a significant cost fix during the erection phase, by way of back charge and possible erection labor.

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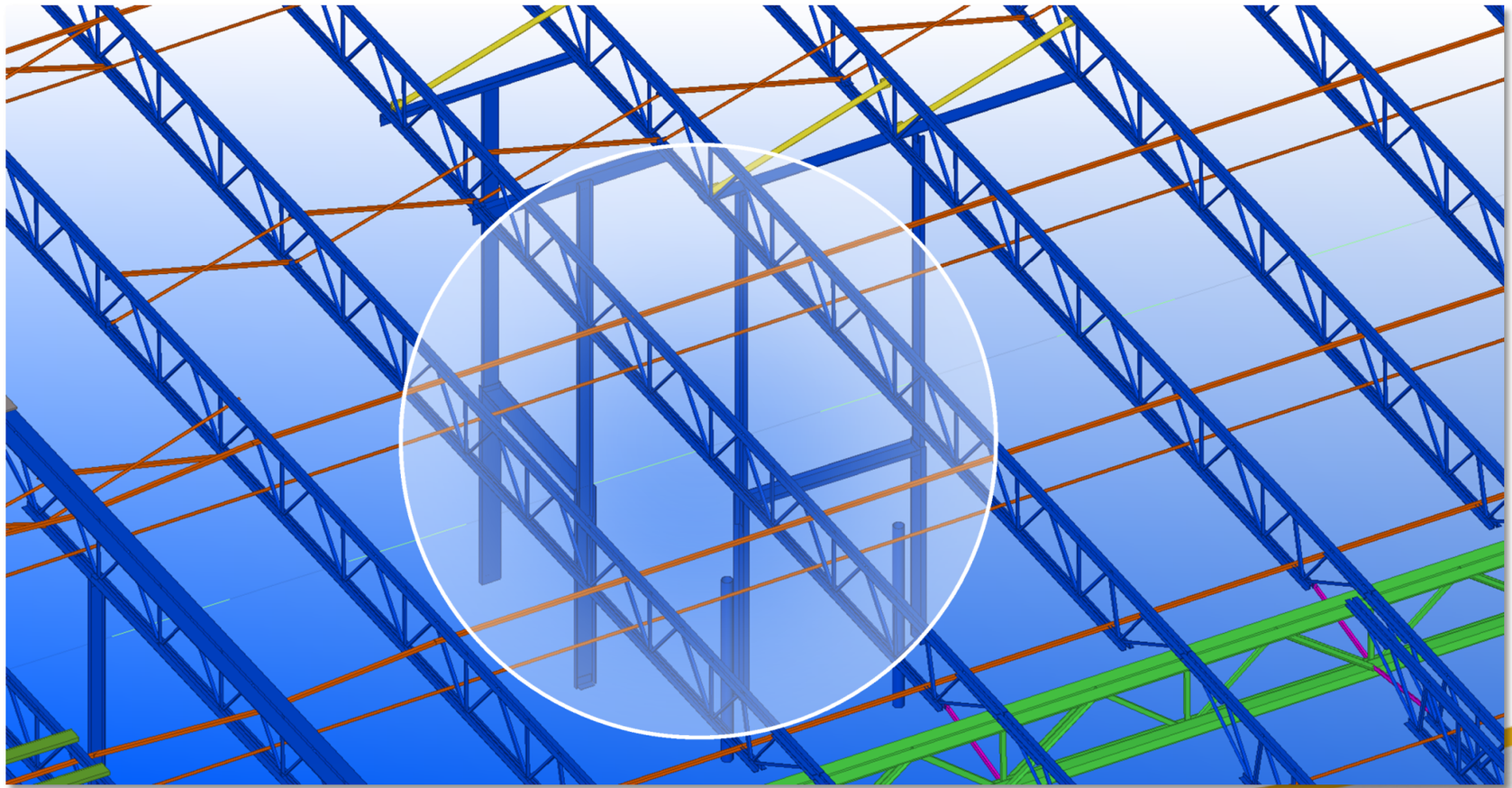
1. How joist design improves the BIM project



In this BIM example, door framing was a point of design discussion. By honing in on the immediate structural environment, the steel detailer was able to precisely integrate the framing of the door within the steel joist chords. By calling up in a highly visual way the actual material sizes, positioning and connection details, this step in the design process was greatly accelerated, compared to using traditional 2D drawings.

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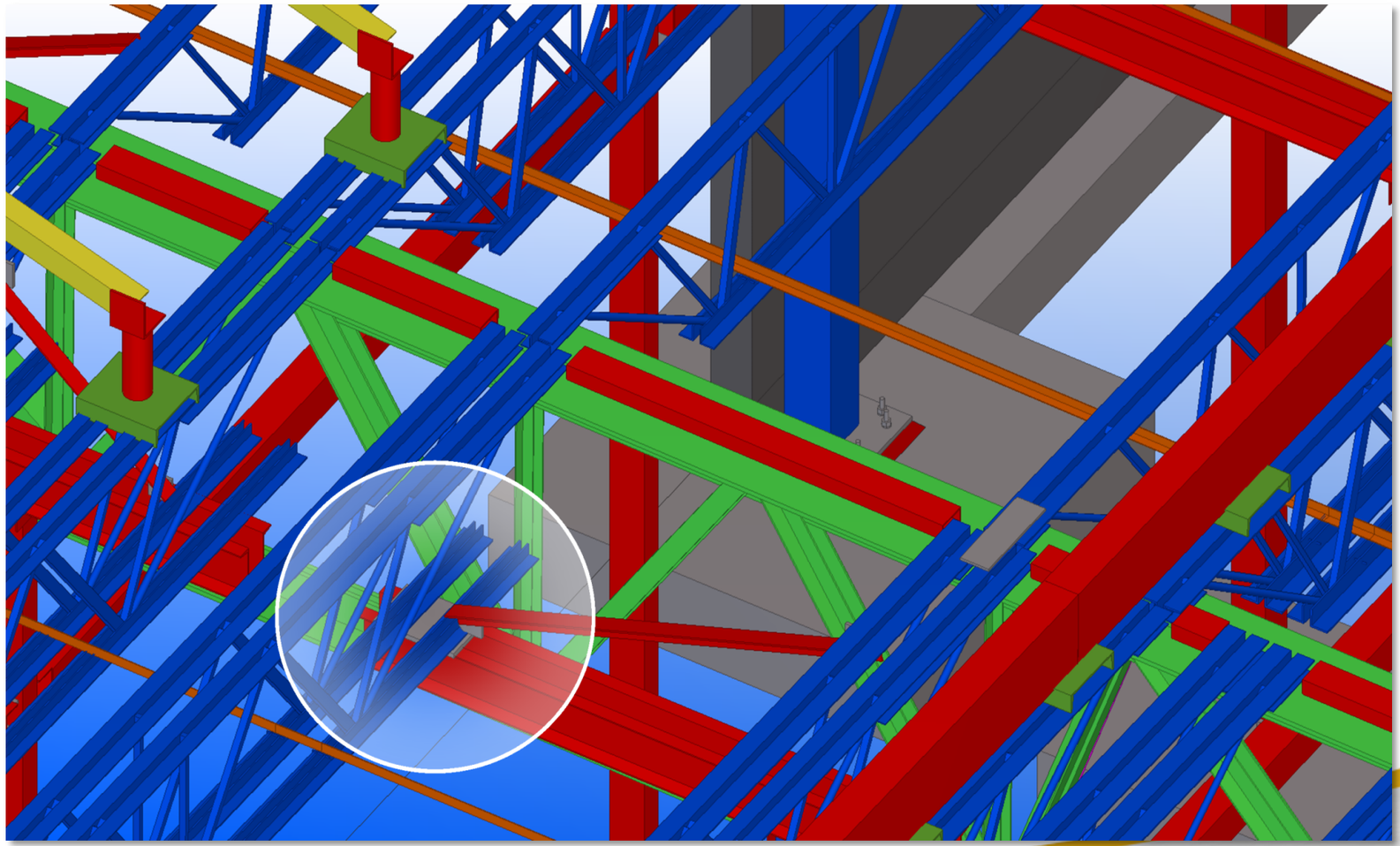
1. How joist design improves the BIM project



On this steel building project, a point of design discussion was in regard to steel joist support here in the model. The design originally called for single joists, not the double joists you see here. During the design phase, the joist engineering team was belatedly advised that the building would have mechanical units located above this point in the design. This required a significant change in load that needed to be accounted for in the joist design. However, increasing the size of the joists would result in deeper joist seat depths, which would have interfered with the roof. Alternatively, the steel joist engineering team determined that the more cost effective solution was to replace the single joists with double joists. In addition, the steel detailer added channel support under the double joists.

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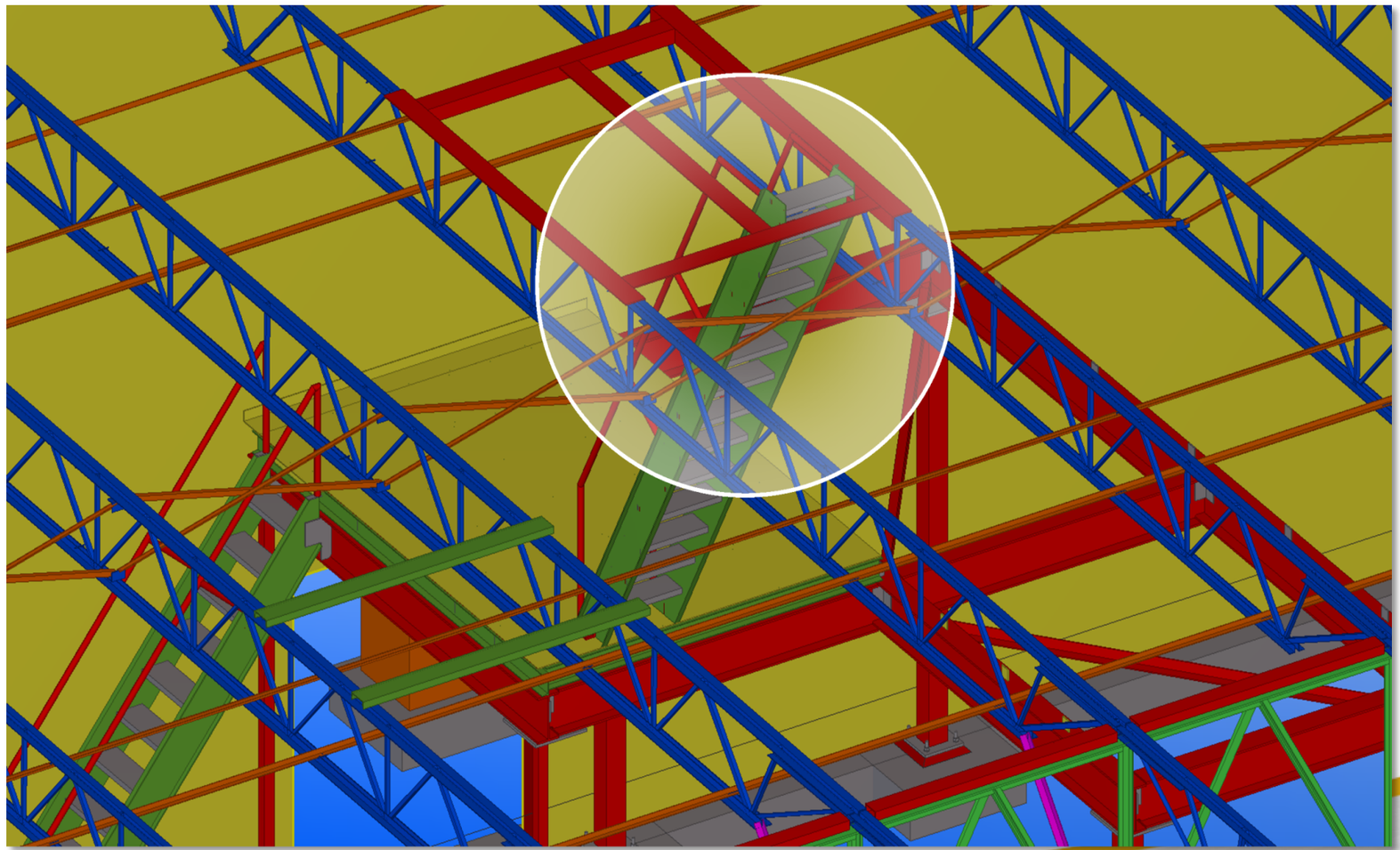
1. How joist design improves the BIM project



On another steel building project, an important design consideration became the location of the many drain supports located throughout the building. Guided by the 3-D model, which included the precise locations and geometry of the steel joists, the detailer efficiently planned out the supports for all of the drains. As you can see in the model, the detailer even integrated a ladder to access the ceiling and roof for future maintenance and replacement accessibility.

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1. How joist design improves the BIM project

Missing Bottom Chord Extension

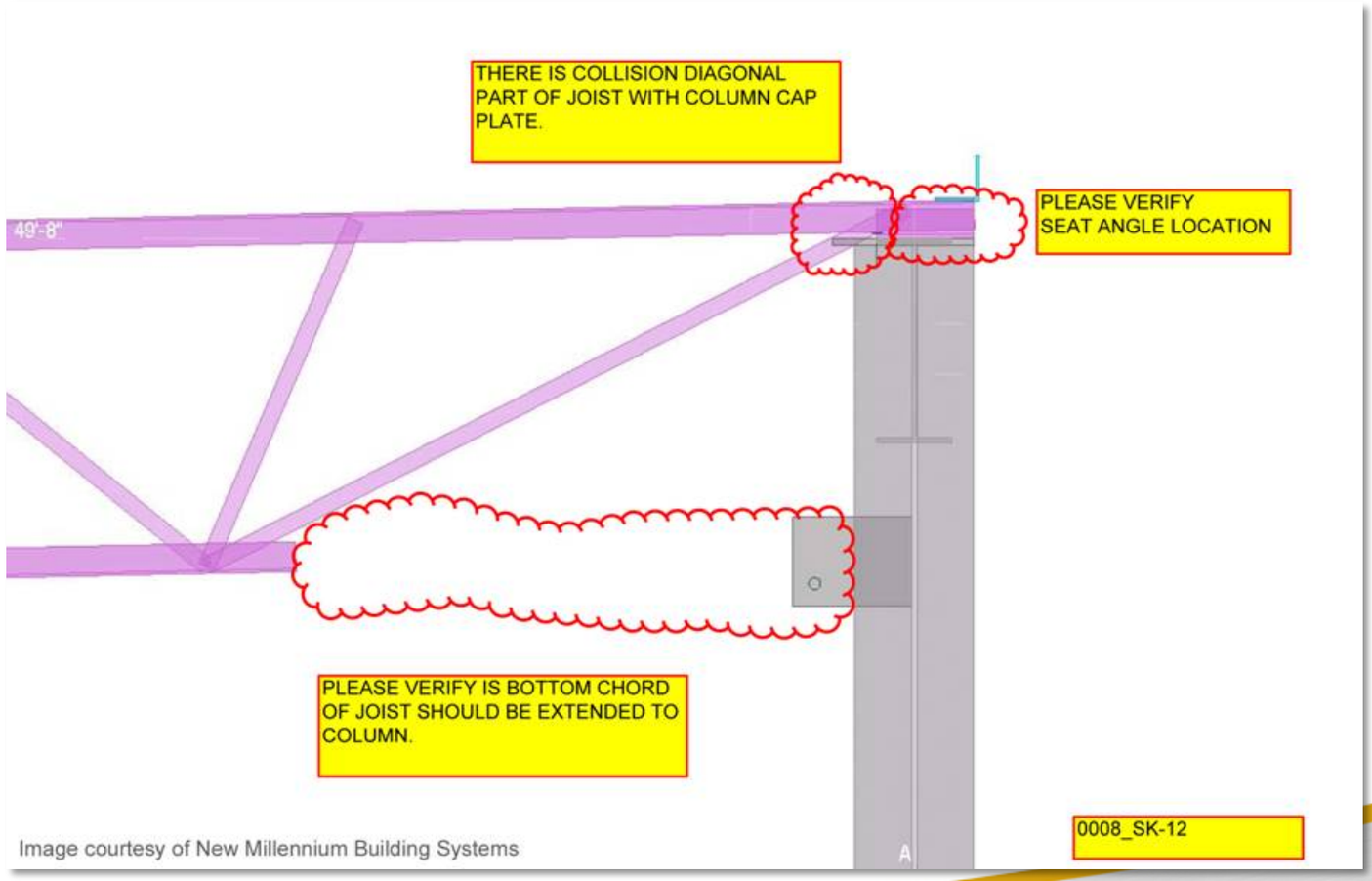
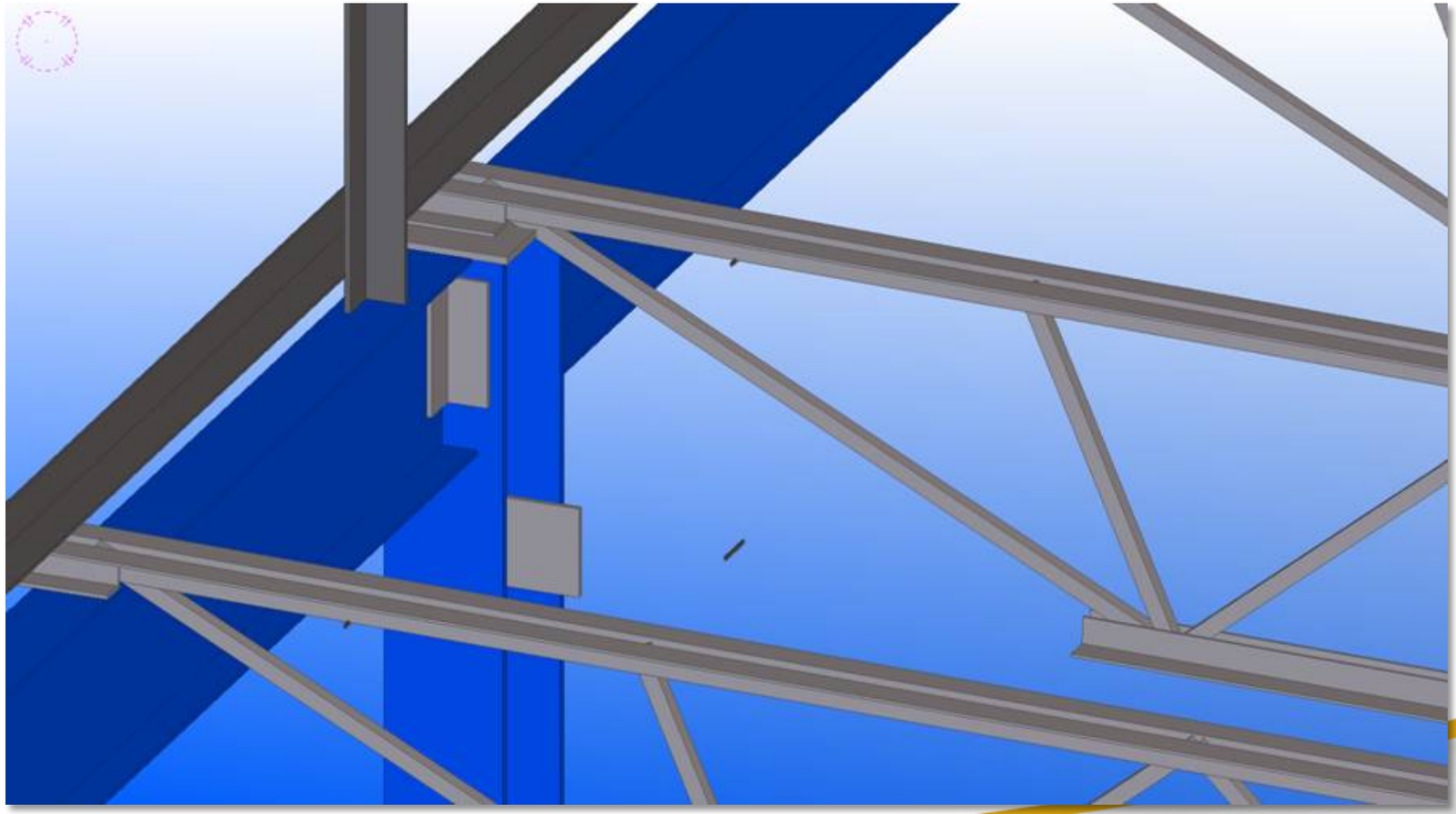


Image courtesy of New Millennium Building Systems

Building design coordination is especially challenging when various trades are involved and those participants are global. For this project located in the US, the structural detailing was sourced overseas to a firm that used Tekla Structures for their modeling, and the steel joists were detailed by the joist company located in the US.

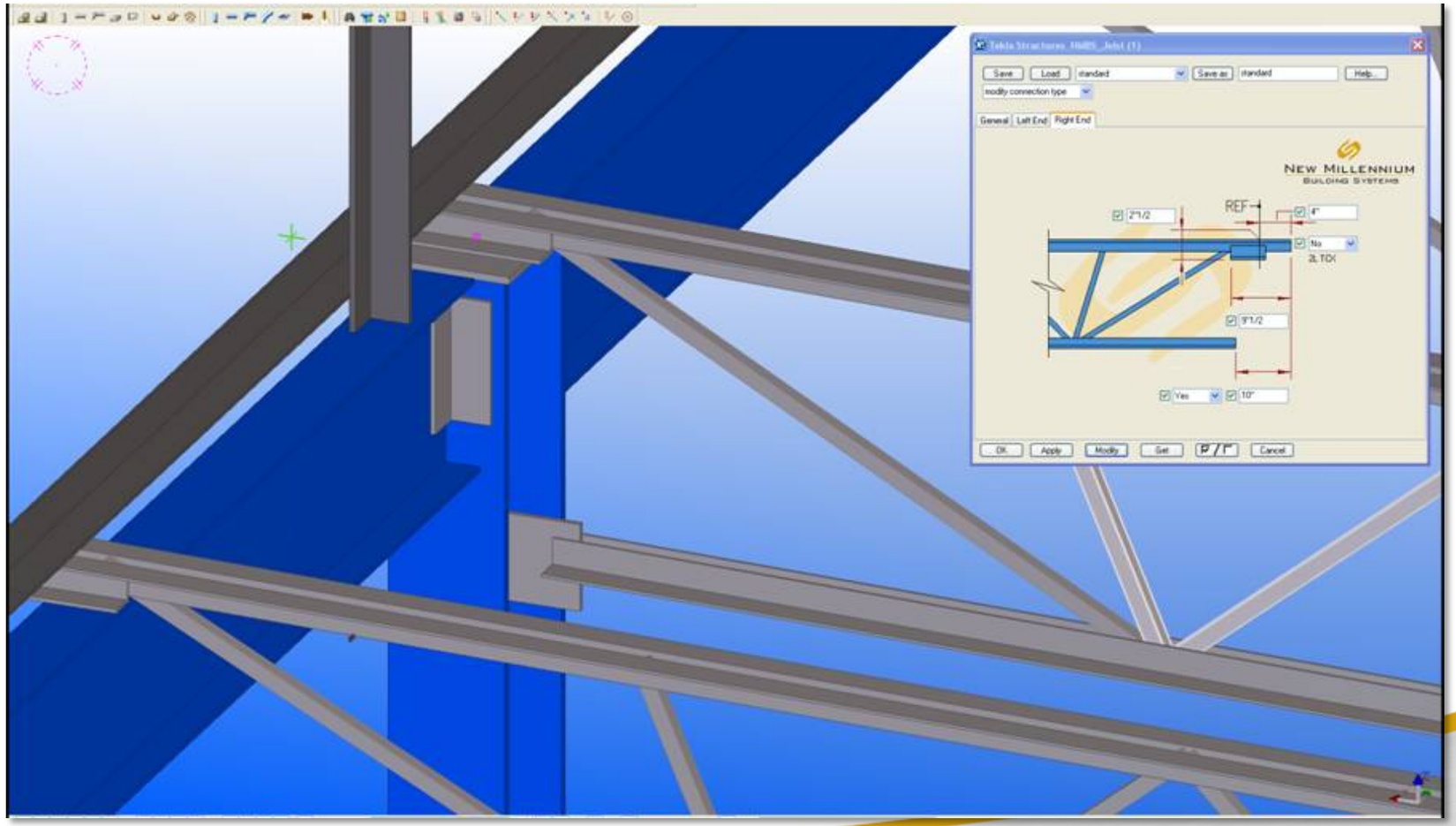
The RFI process soon focused on this connection point within the design. The detailer overseas provided this sketch to the joist team in the US. The question being, a bottom chord extension on one of the joists may be missing and there may be a problem with the bearing angle.

Missing Bottom Chord Extension



With the 3-D model as a reference, the joist detailer immediately located the joist in question and understood that the section information was missing from the model.

Missing Bottom Chord Extension



The steel joist detailer quickly corrected the design and sent the model back to the structural detailer with the correction. The improved RFI process prevented a time and cost disruption to the erection phase of the project.

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1. How joist design improves the BIM project

- Safety – Minimization of waste, not as much stock piling
- Improved schedules providing flexibility
    - Can reduce the number of trucks/people on a job site
- Logistics – Better overall management of construction
- Improved accuracy in construction

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The benefits of BIM steel joist design extend beyond design improvement and cost prevention during the erection phase. BIM has fostered improvements in the very process of project design and development. Building owners and all who are involved in the project are beginning to see improvements not heretofore seen.

Improved structural steel design contributes to safer erection, due to a reduction in oversights related to a range of variables including, proper fit, loading, and the prevention of unnecessary on-site fabrication.

Waste can be minimized and stock piling can be reduced. Schedules can be better managed, and with greater flexibility. Outcomes can include a reduction of truck deliveries and on-site material handling. Construction overall is made more manageable, with potential for improvement at every phase.

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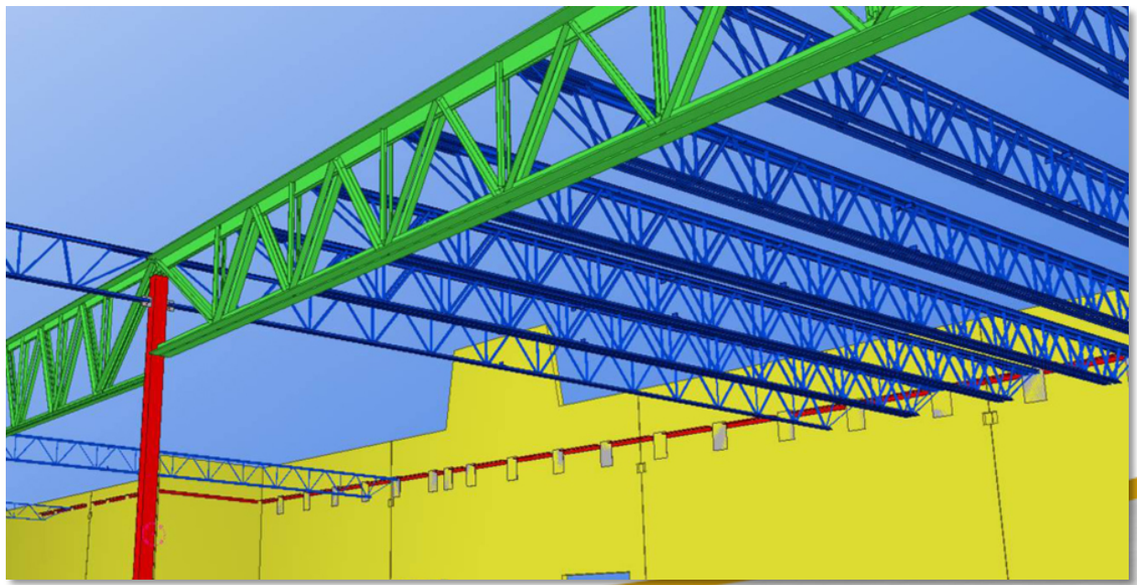
1. How joist design improves the BIM project

- Better building design
- Improved schedules
- Tool for post construction activities
    - Facilities management (additions and/or revisions)
- Cost reductions
- Virtual Building



For all of the reasons outlined here, BIM joist integration brings particular value to the building owner, who benefits from a better designed building and more time-and-cost efficient project delivery. Moreover, the BIM model ultimately belongs to the owner, who can use the virtual model for subsequent facility management activities ranging from moves, adds and changes, to HVAC maintenance and replacement.

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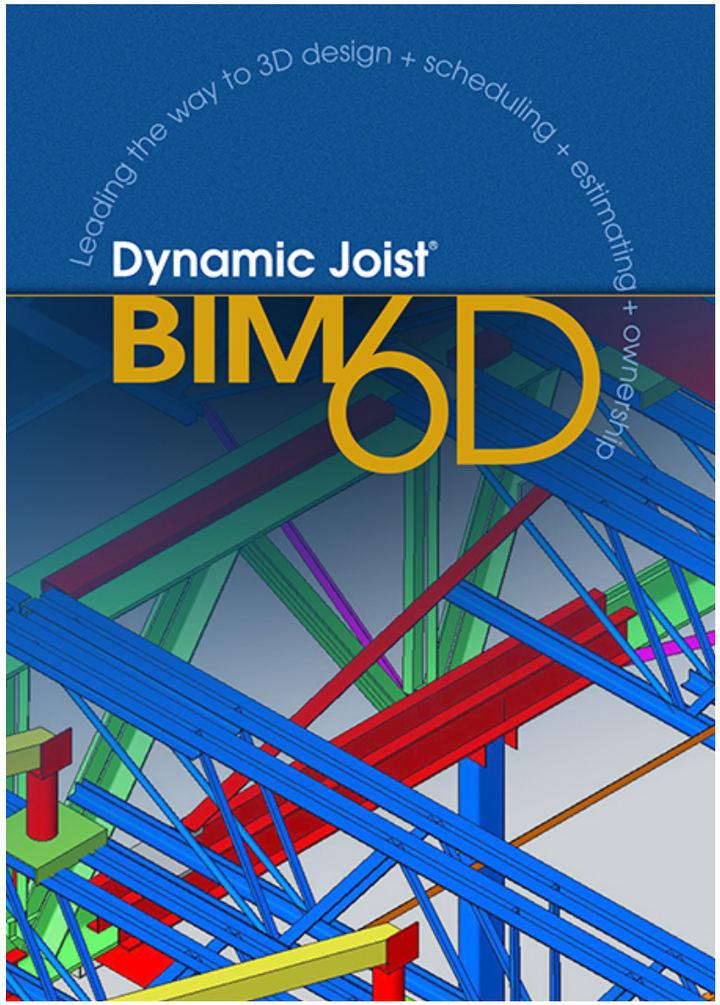
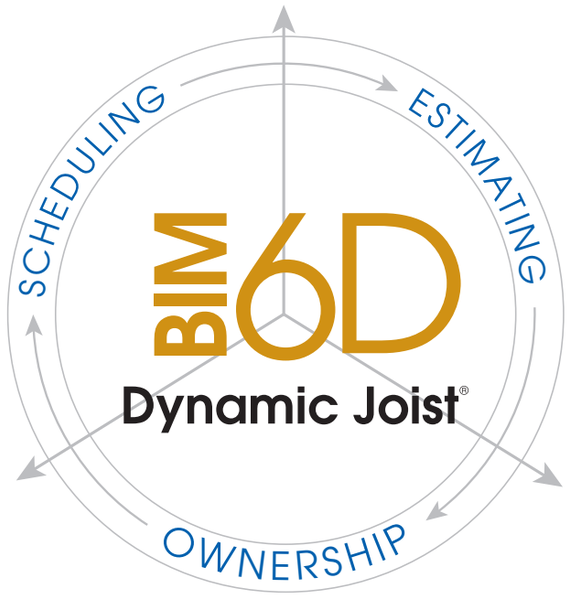
1. How joist design improves the BIM project



- 4D, 5D, and 6D implementation
  - 3D = x,y,z axis
  - 4D = Scheduling
  - 5D = Cost
  - 6D = Facilities Management



Initially, BIM was considered a 3-D tool only, owing to the virtual design aspect of the software itself. But in the course of BIM adoption, everyone involved has discovered that the very process of project delivery has been improved by BIM. BIM is no longer considered “3D” only. The concept of BIM “6D” encompasses and improves the functions of scheduling, cost, and facilities management. BIM 6D supports the further exploration and understanding of how building design and construction can be improved. This exploration will be of particular interest to non bid-build project delivery approaches, including design-build and integrated project delivery (IPD), which encourage early design collaboration, including such mission-critical contributions as the steel joist and deck engineering.

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Learning Objective #2

2. **How BIM supports steel joist design:** key benefits and two methods of adoption – Partial BIM, Full BIM

BIM has had a significant impact on steel joist design, engineering, manufacturing and delivery. An optimized BIM approach encourages and often requires earlier design engineering participation by the steel joist and deck company. The steel joist and deck design phase moves upstream. Information among key trades is shared earlier, and this has fostered an increase in true team performance. At the same time, design changes that would traditionally cause delays are more efficiently addressed.

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2. How BIM supports steel joist design

- Changes to the traditional work flow
- Processes have moved upstream (ie. Design)
- Sharing more info than we normally share with other trades
- Interaction with more trades
- More flexibility and agility

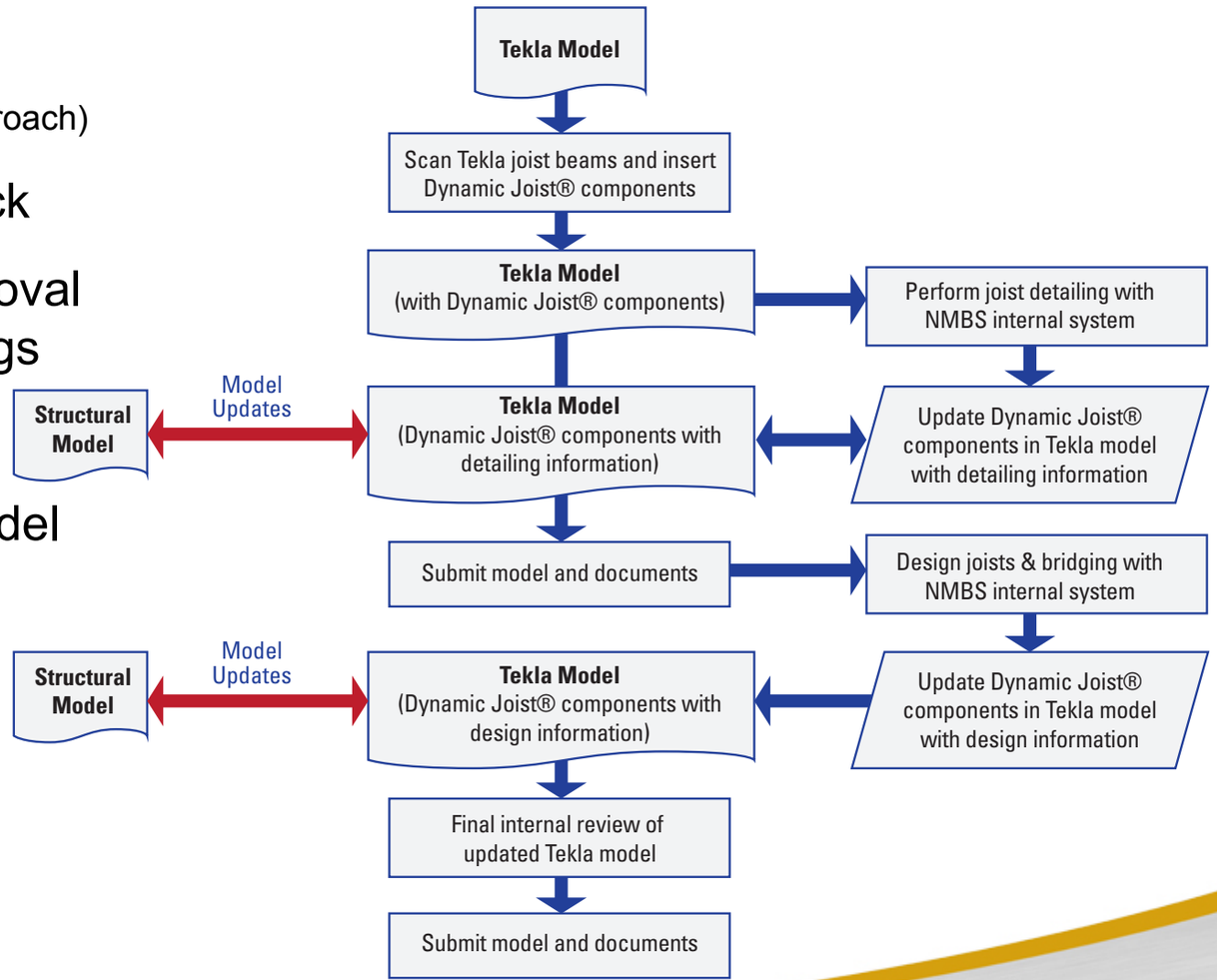
Joist manufacturers have their own ways of handling their BIM projects, but their goal is the same: Provide a complete and accurate model of the joist system. However, as a process, BIM has been applied in different ways, and this is often due to the comfort level of those driving the project.

2. How BIM supports steel joist design

Partial BIM

(follows traditional 2-D approach)

- Detail and Check
- Submit for approval with 2D drawings
- Design
- Submit final model



Some projects request a partial BIM approach, which closely follows the traditional 2D approach to building design and construction. For example, on a partial BIM project, the joist company may detail and check the job, then submit the model with 2D drawings for approval. At this point, the joists in the model are only partially complete, because the joists have not been designed. Material and geometry of the panels are not final. It is not until an approval is issued, that the joist company designs the job and submits the final model with the as-built information.

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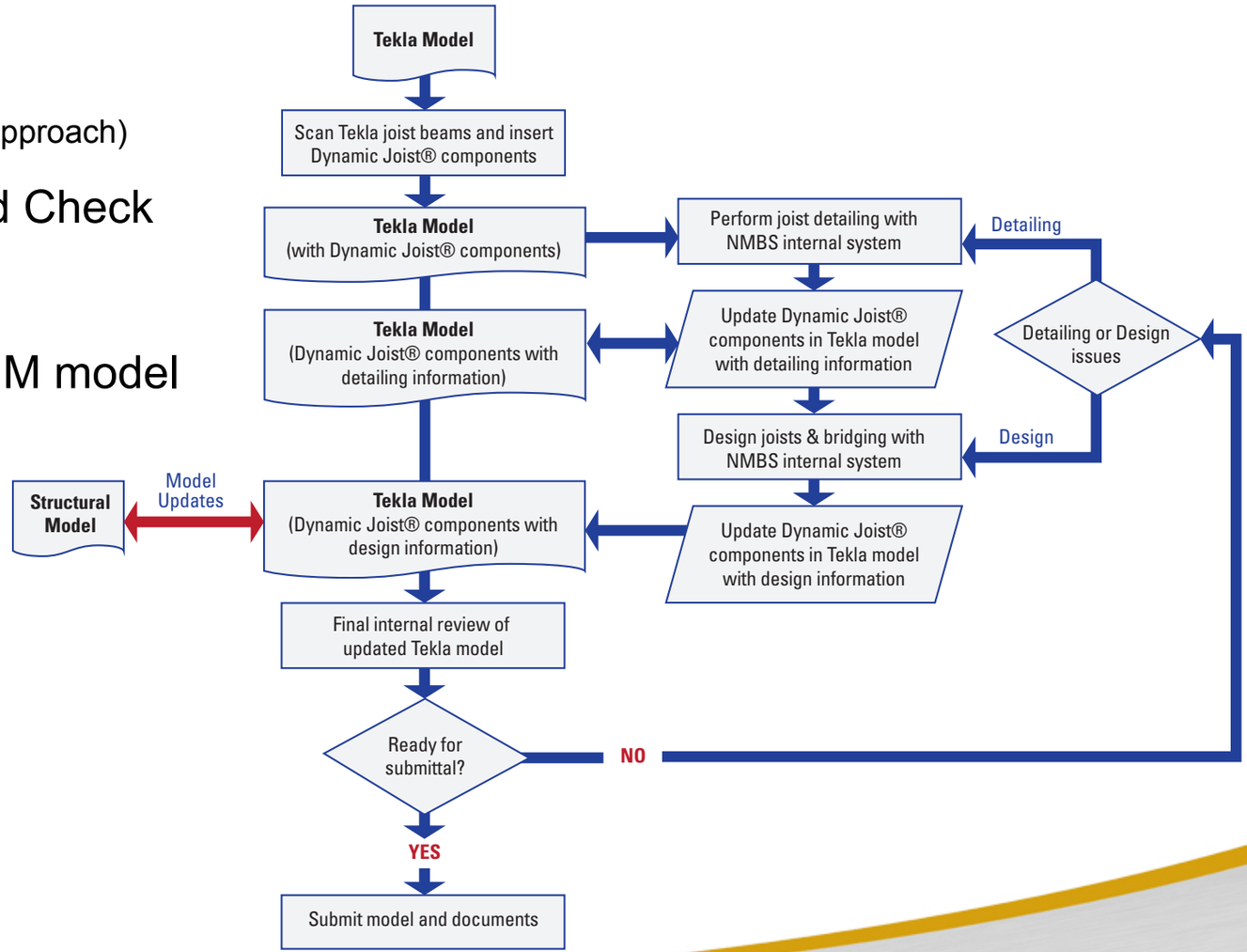
2. How BIM supports steel joist design

Full BIM

(embraces full 3-D approach)

- Detail and Check
- Design
- Submit BIM model



On a true full BIM project, the steel joist company will detail and review the joist requirements, then create the design before submitting the BIM model. This approach is more holistic, and requires that the joist manufacturer be involved early in the project as a true collaborator on early project design cost and performance questions. The level of BIM application is also decided during a joist kick-off meeting

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3. **BIM process management steps:**
   Joist Kickoff Meeting,
   Ongoing Coordination Meetings,
   Pre-Construction Meetings.

BIM joist process management requires disciplined communication, starting with a joist kick-off meeting among all participants. For example, an early point of agreement is how the joists will be referenced by the steel detailer, methods of file exchange, and the model formats used.

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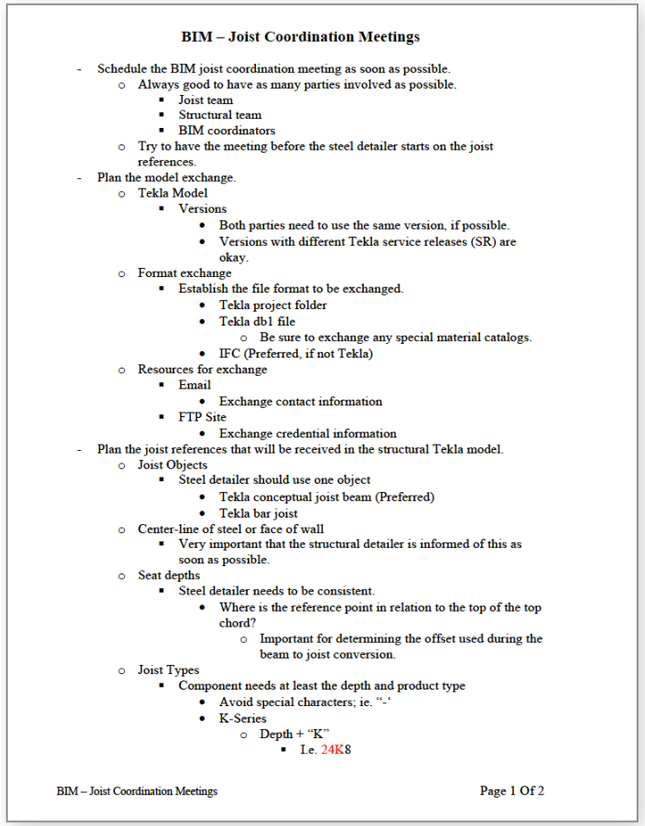
3. BIM process management

- BIM Joist Kick-off Meeting
  - Process preparation
- BIM Coordination Meetings
  - Conducted throughout project life cycle
  - Detailing/Modeling and design coordination
- BIM Pre-Construction Meetings
  - Conducted after final models submitted
  - Various trades participate
  - Models from the various trades imported into one master model for clash detection.

Communication via NavisWorks™, Tekla BIMSight™



BIM – Joist Coordination Meetings

- Schedule the BIM joist coordination meeting as soon as possible.
  - Always good to have as many parties involved as possible.
    - Joist team
    - Structural team
    - BIM coordinators
  - Try to have the meeting before the steel detailer starts on the joist references.
- Plan the model exchange.
  - Tekla Model
    - Versions
      - Both parties need to use the same version, if possible.
      - Versions with different Tekla service releases (SR) are okay.
  - Format exchange
    - Establish the file format to be exchanged.
      - Tekla project folder
      - Tekla db1 file
        - Be sure to exchange any special material catalogs.
      - IFC (Preferred, if not Tekla)
  - Resources for exchange
    - Email
      - Exchange contact information
    - FTP Site
      - Exchange credential information
- Plan the joist references that will be received in the structural Tekla model.
  - Joist Objects
    - Steel detailer should use one object
      - Tekla conceptual joist beam (Preferred)
      - Tekla bar joist
  - Center-line of steel or face of wall
    - Very important that the structural detailer is informed of this as soon as possible.
  - Seat depths
    - Steel detailer needs to be consistent.
      - Where is the reference point in relation to the top of the top chord?
        - Important for determining the offset used during the beam to joist conversion.
  - Joist Types
    - Component needs at least the depth and product type
      - Avoid special characters; ie. "-"
      - K-Series
        - Depth + "K"
          - I.e. 24K8

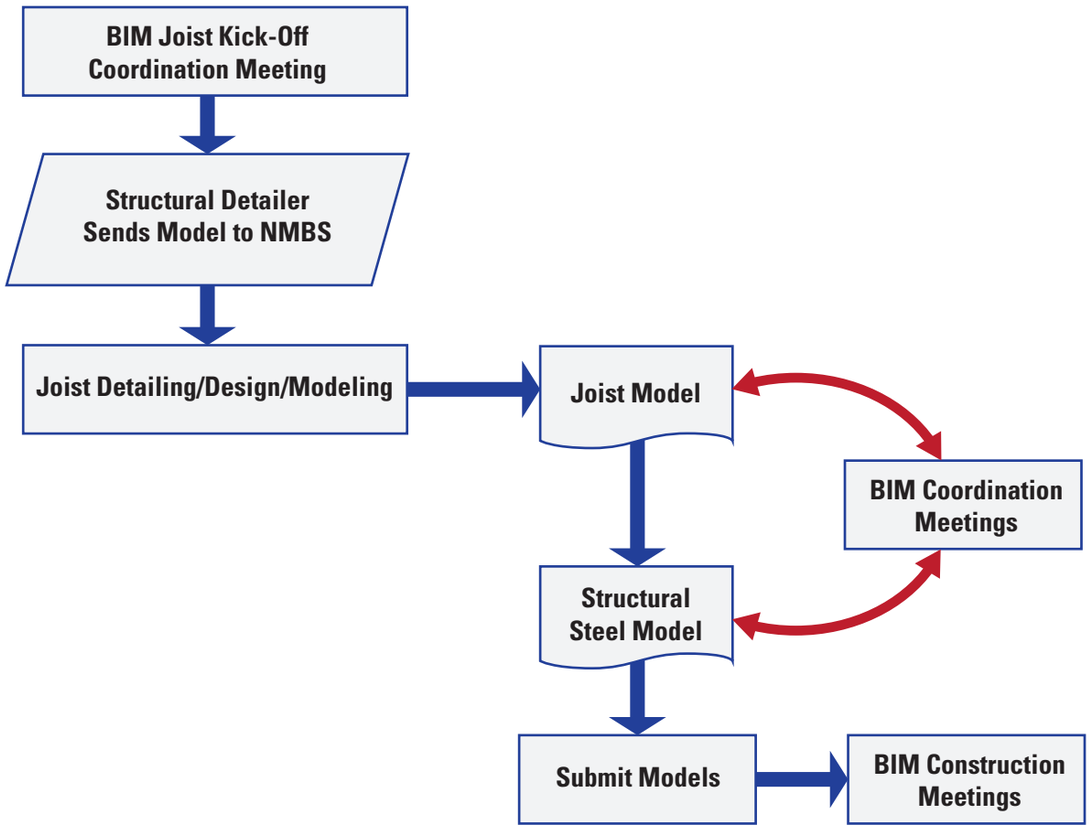
BIM – Joist Coordination Meetings Page 1 Of 2

After the initial joist kick-off meeting, coordination meetings continue throughout the life of the project, including the steel joist detailing and design phases. Trust among participants is established. Questions are raised and answered promptly. Errors are efficiently found and resolved. Unnecessary costs are prevented.

Pre-construction meetings bring together trades that have often never communicated with each other before, but whose activities have long been interdependent. Progressive general contractors are recognizing the cost/performance benefits of this synergy.

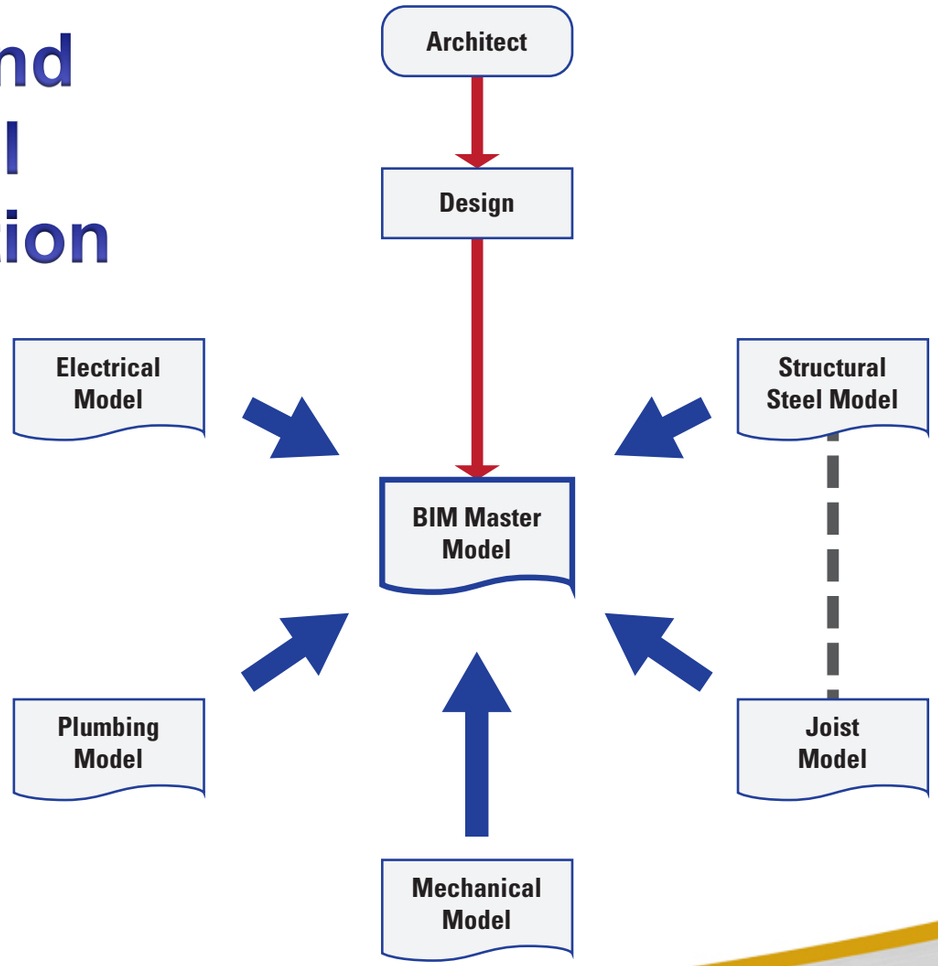
The final models submitted by the different trades are imported into the master model. This requires the exchange of universal file formats, like buildingSmart's IFC format. The various trades then navigate through the model together, looking for potential problems or clashes. Common tools to accomplish this communication are NavisWorks and Tekla BIMSight. BIM construction meetings are usually conducted over the web, via WebEx or Go-To-Meeting.

Process Overview



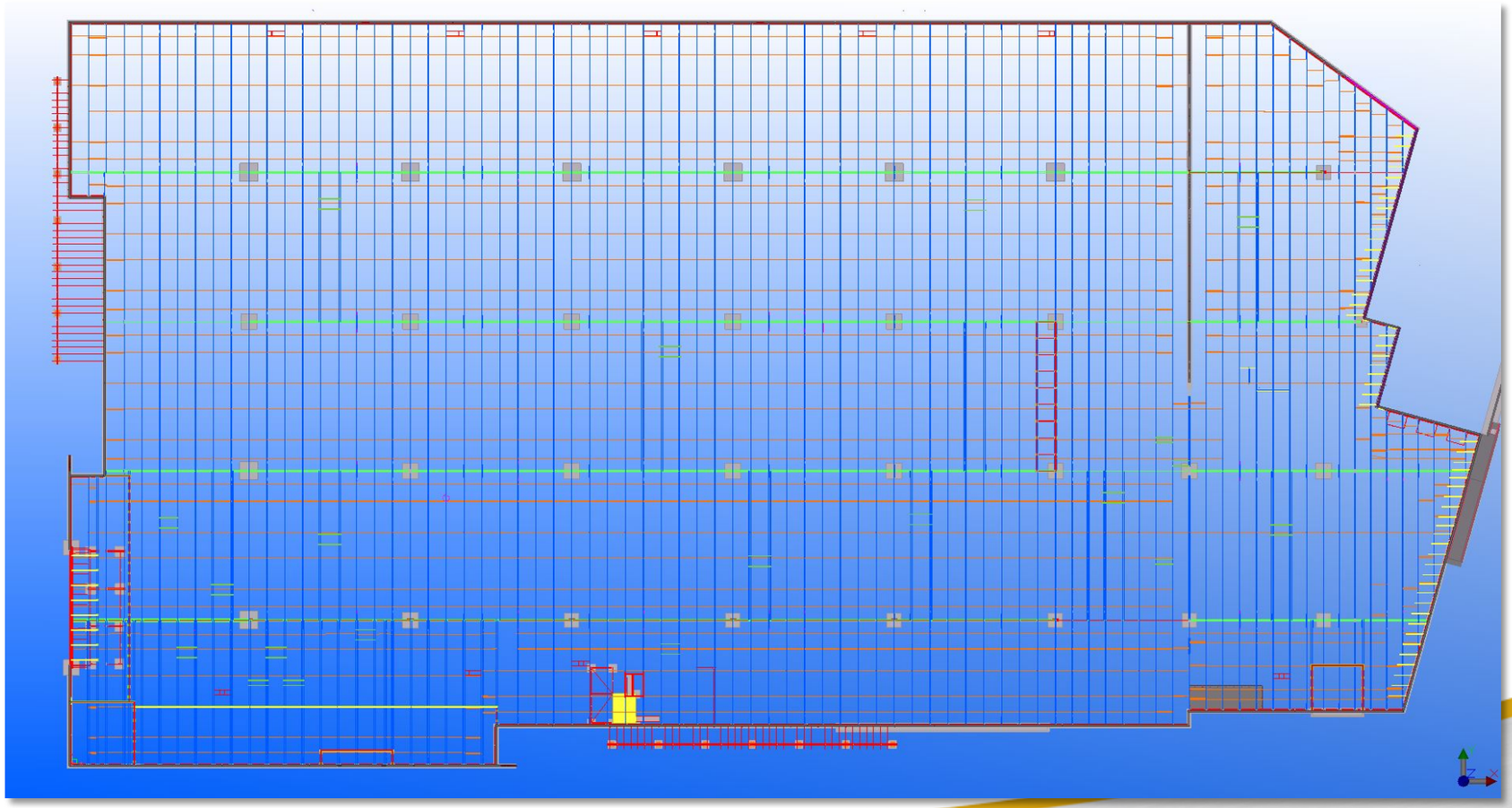
This chart more clearly shows the BIM process for steel joist design, starting with the joist kick-off meeting. The project's structural detailer sends their model, containing the steel joist references, to the steel joist company's detailer. The joist detailing and design process begins here. During this process, BIM coordination meetings among the structural and joist detailers are made efficient by the model reference. Once the final joist model is ready, it is submitted to the customer for approval. Upon approval, the model is imported into the master model. The completed design can now be used for construction, to be referenced during BIM construction meetings.

Joist model and structural steel model integration



Here is a further demonstration of how the steel joist company supports an optimized, collaborative BIM model. Notice the dotted line between the structural and joist models. The joist models are submitted together for the master model. Models are imported from various trades to generate the master model. The master BIM model changes as conflicts are resolved. When a design change is made by a participating trade, that participant resubmits their model to be imported into the master model. The facilitator of the master model removes the trade's outdated model and imports the new model. BIM construction meetings give the team an opportunity to correct issues before construction has started.

Detailing & Modeling

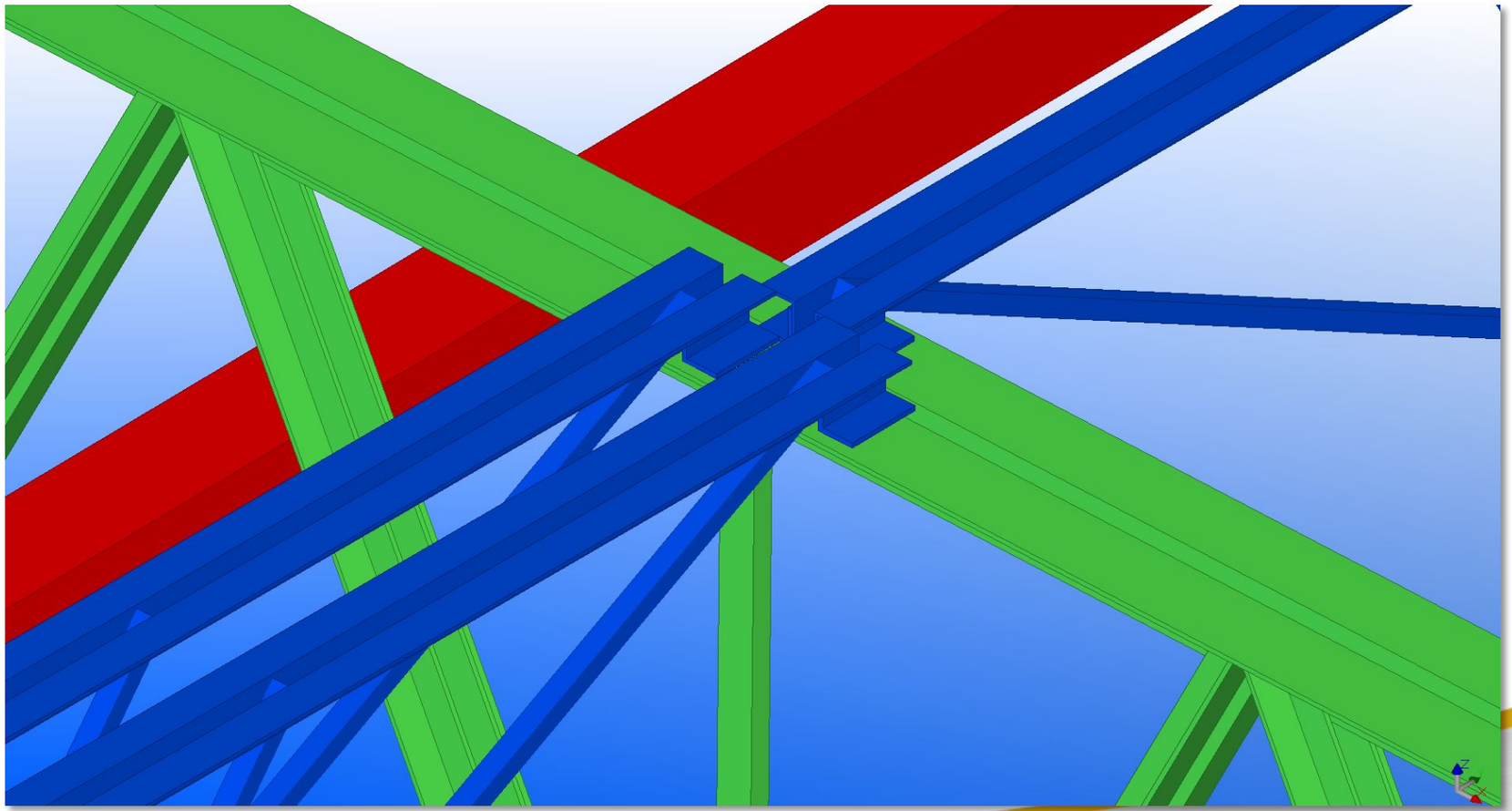


The joist detailing and modeling process can start different ways. The approach is decided during the initial coordination meeting. If the steel detailer's model has enough information for the joist detailer, that model will be used as the initial joist model. Otherwise, the joist detailer will start the joist model from scratch.

It is more beneficial to start with the steel detailer's model, for several reasons. The structural steel in the model helps with the joist detailing. The joist detailer has the visual of how the joists fit in the framing. If the steel detailer has inserted joist references in their model, it saves the joist detailer in layout time. This trims time off the detailing process.

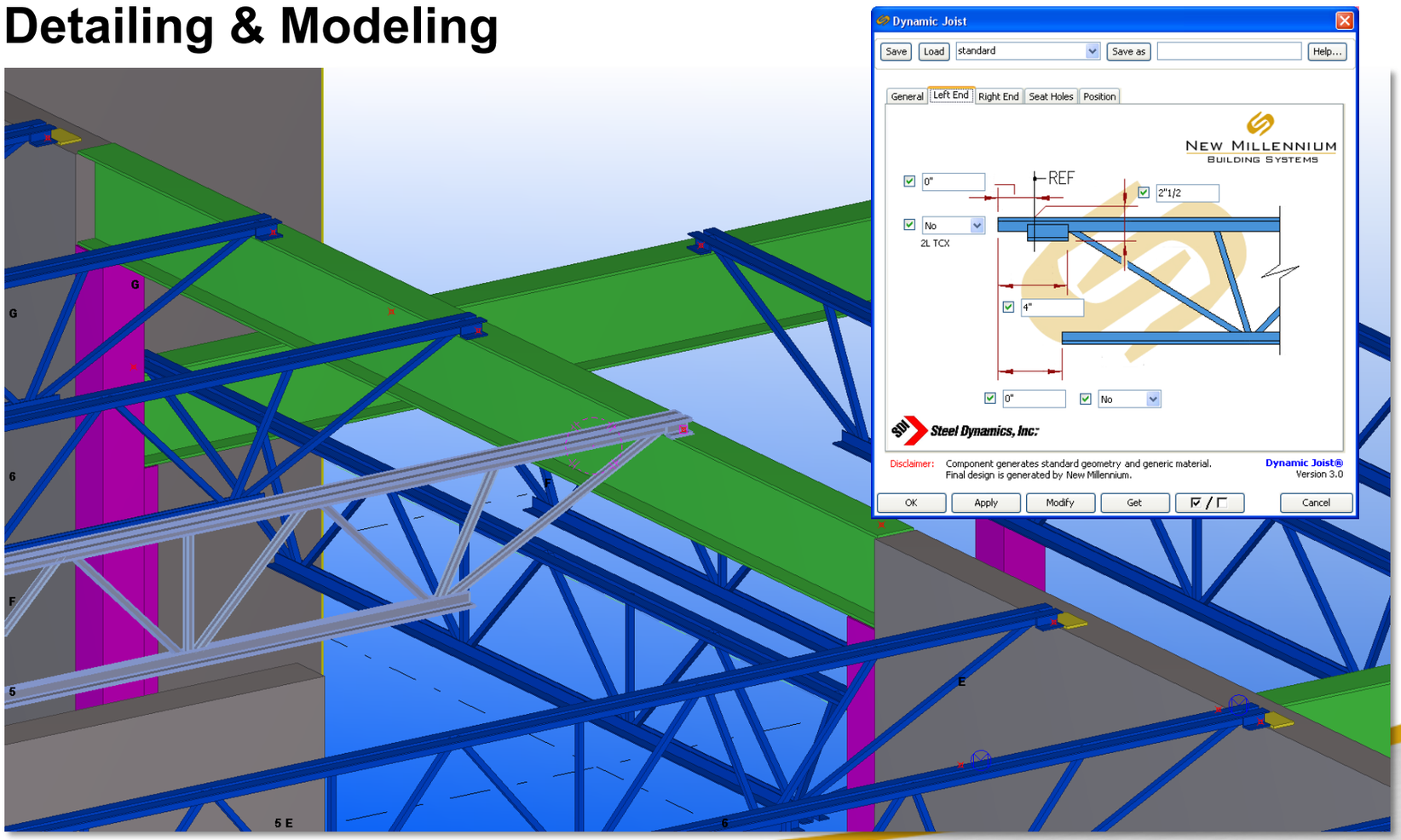
Regardless of how the joist model begins, during the detailing process the steel joists are laid out in the model. Sections are established for the ends of the joists. And loads are coordinated.

Detailing & Modeling



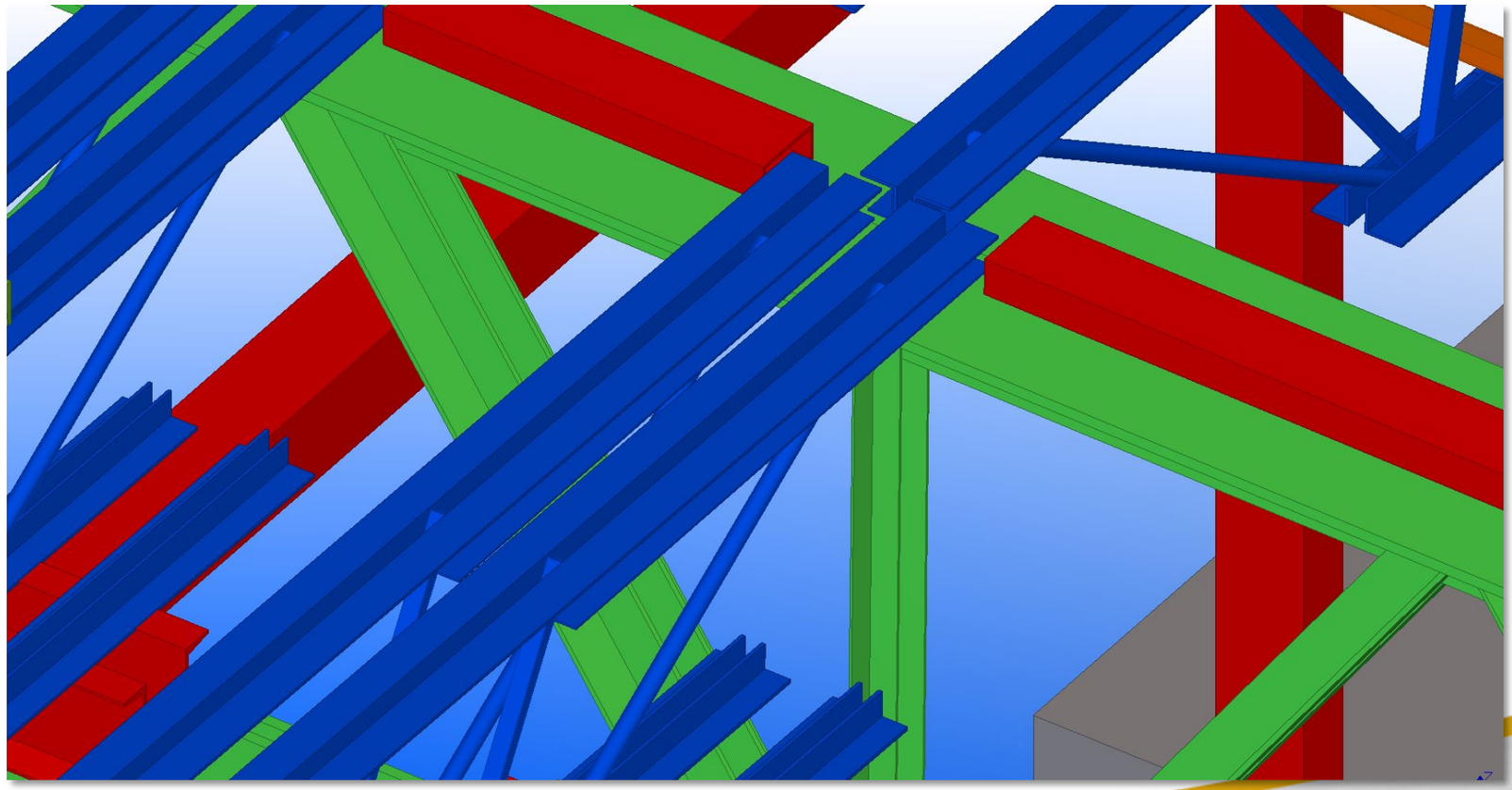
3D visualization is a valuable tool while detailing the steel joists. The detailing information is refined to prepare for the design of the joists. During the detailing process, the joists in the model are generic. Joist depth and length, along with section information, are the main pieces of information established during the detailing process. The exact geometry and material sizes are not established until the joists have been designed.

Detailing & Modeling



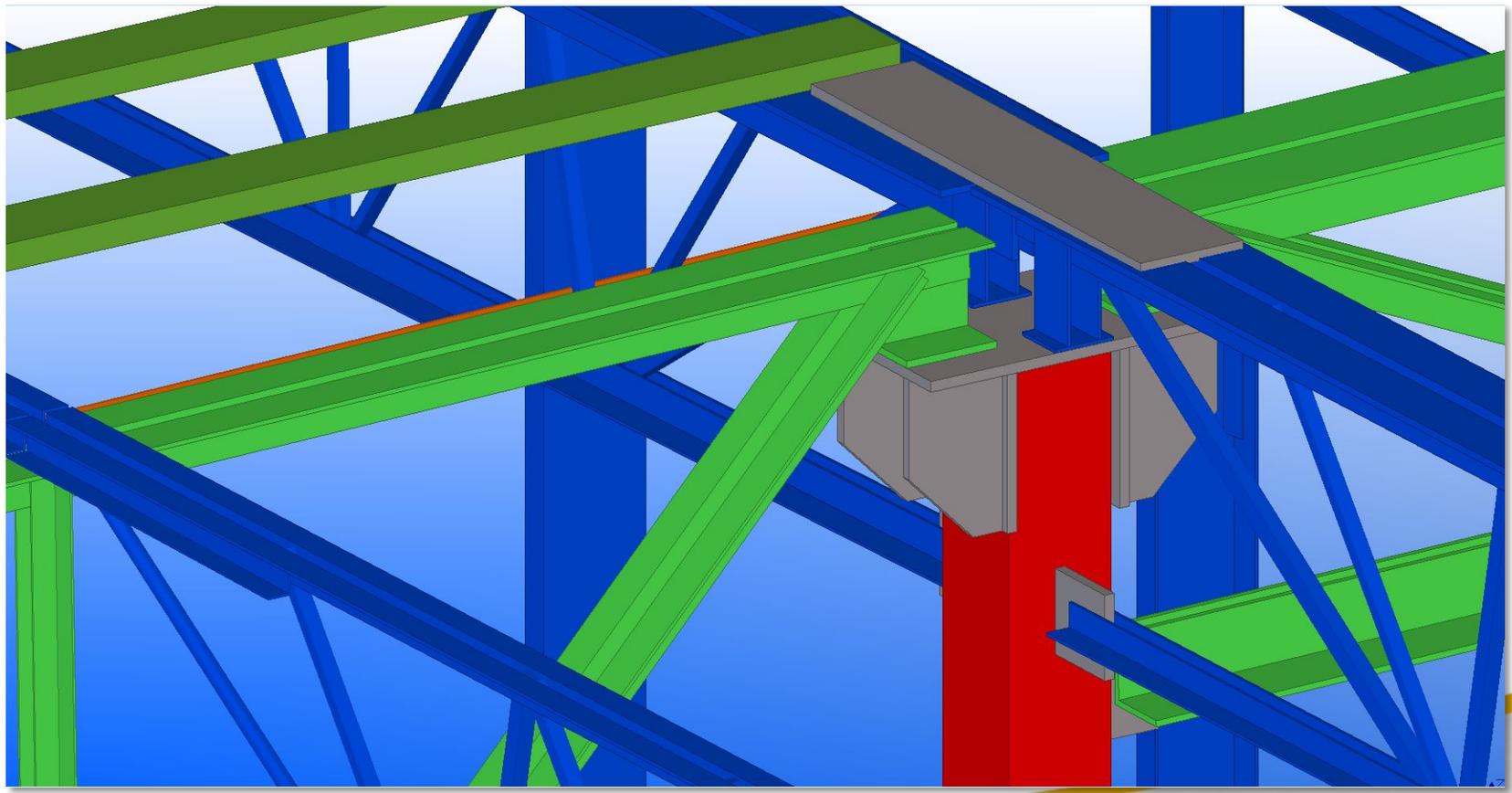
Steel joist manufacturers have their own methods and tools to model their joists. This may be through an interface, an export from their system, or manually modeled steel members.

Design



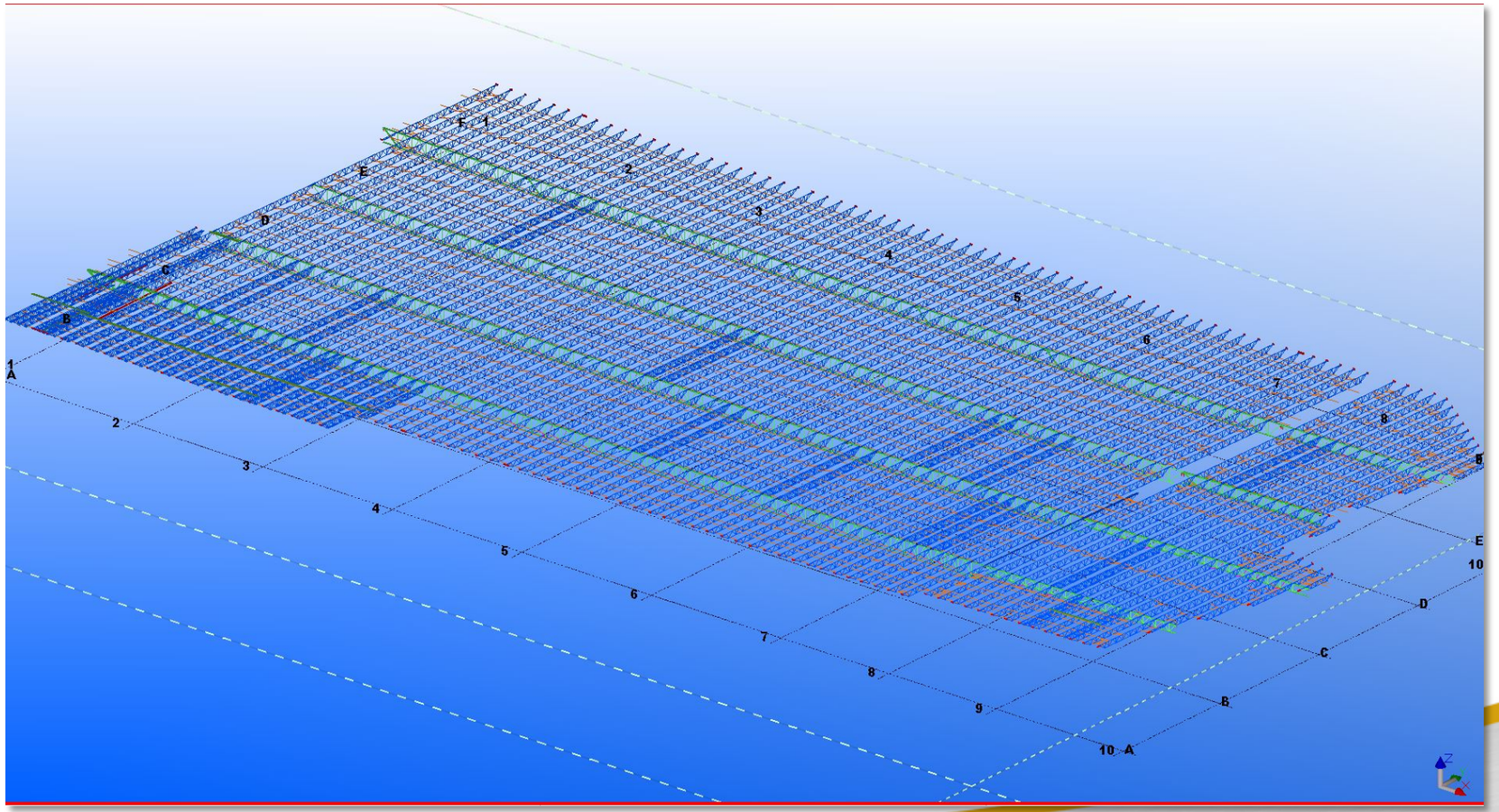
Trained engineers design the steel joists using software specifically for designing steel joists. The engineer generates the best design for the application, using the detailing information in the model. The joists in the model are updated with this design information. This is the “as-built” information. The joists contain the material sizes for the joist members, the joist seat sizes and configurations, and the web panel locations.

Design



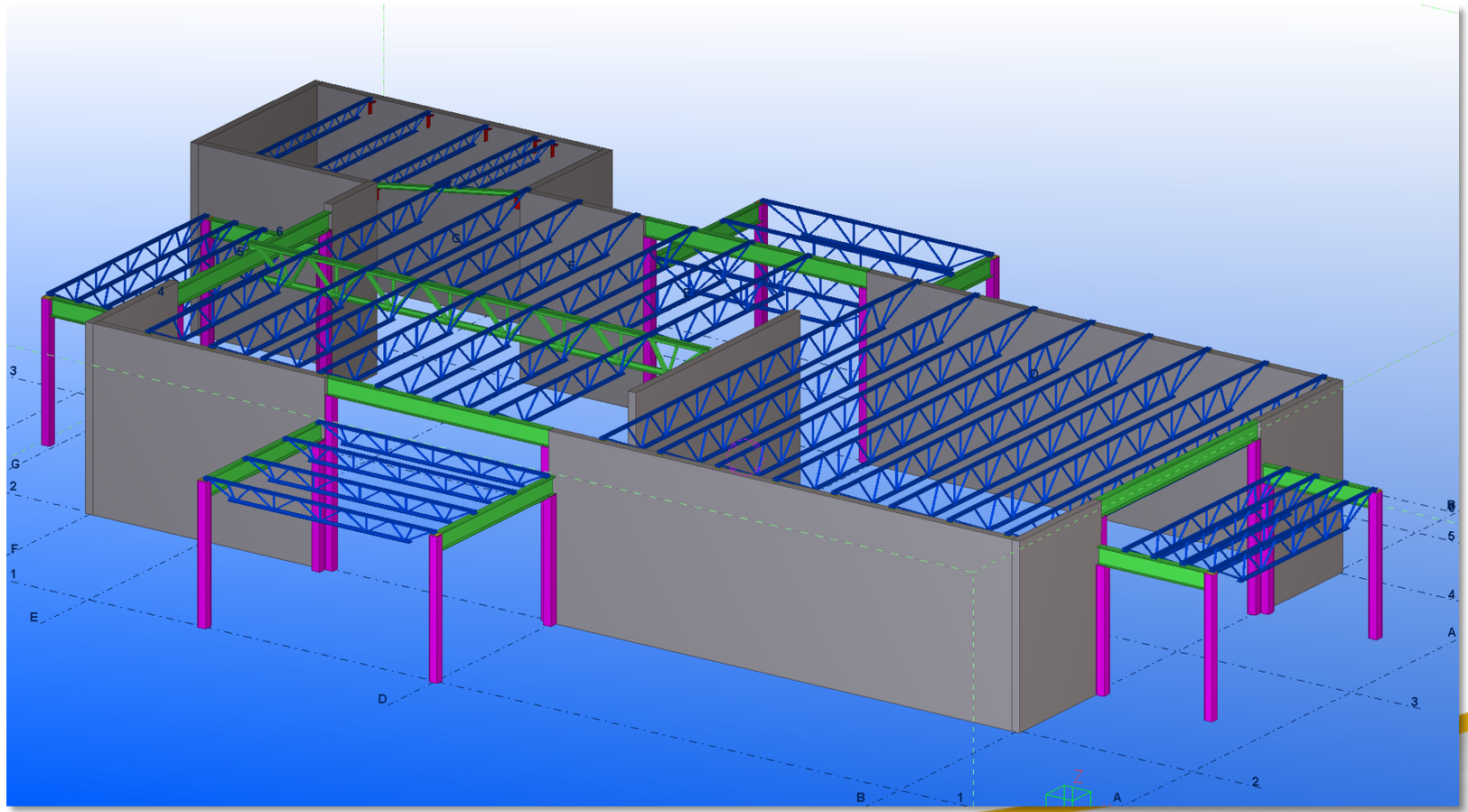
It is not unusual for the steel detailer or the joist detailer to request updated portions of the model once the joists have been designed. This provides visual verification of the steel fit-up. In this example, you can see different joist seat designs and how the steel comes together. Joists are bearing on the column. Joist bottom chord extensions are connecting to the column.

Design



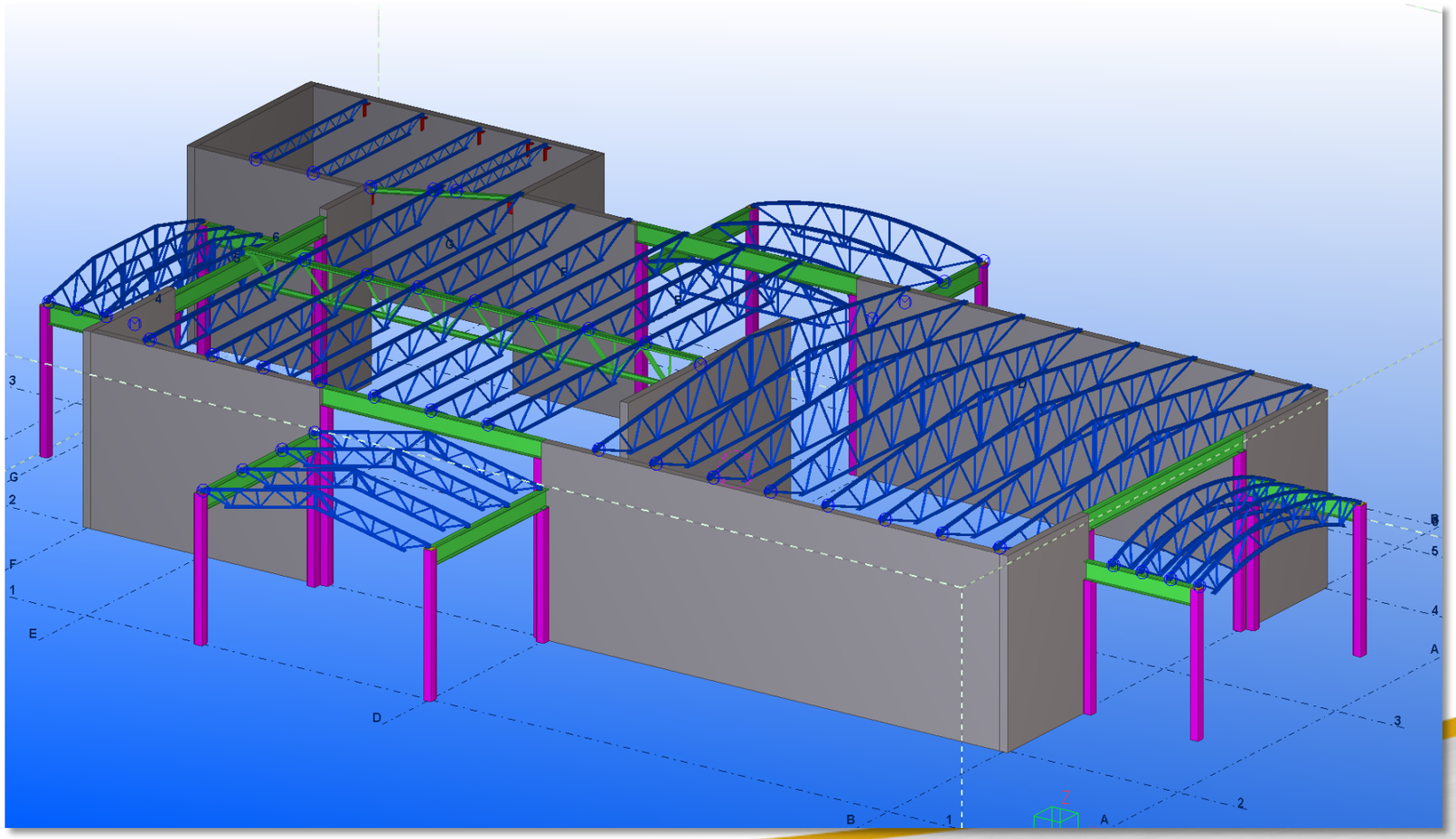
Once the joist model has been updated with the designed joists, it is ready for delivery. The joist system, excluding the structural steel, is delivered to the customer. The model is delivered in the format established during the initial coordination meeting. The joist model can then be imported into the master BIM model for the project.

Design

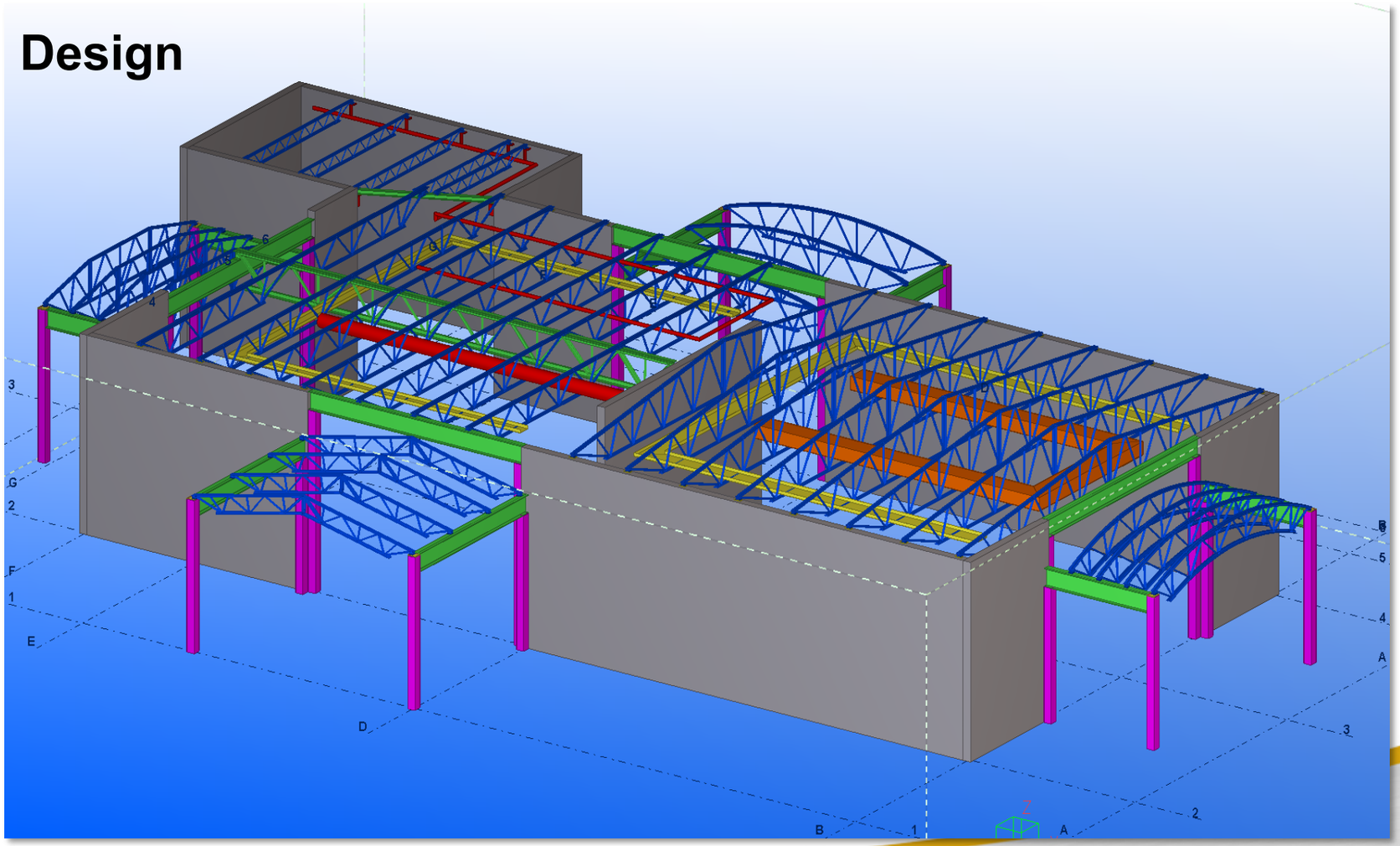


Let's show the transformation of the steel joists as they go through the detailing and design process. Here you see standard or generic detailed joists, which lack actual dimensions and related design information.

Design



As the joists are detailed and designed, the joists in the model are updated and you can now see the fabricated joists, which have actual dimensional data and connection information. This is especially helpful when the project requires the use of special profile joists, as seen in this example. So now all other trades referencing the model can plan around real structural information.



You can see how components such as ductwork and piping can be coordinated through the web system of the joists. Notice the cable trays running through the webs. The fabricated joists in the model enable the design of the cable trays within the web system. This could lead to raising the ceiling of a room, and a cost savings in material.

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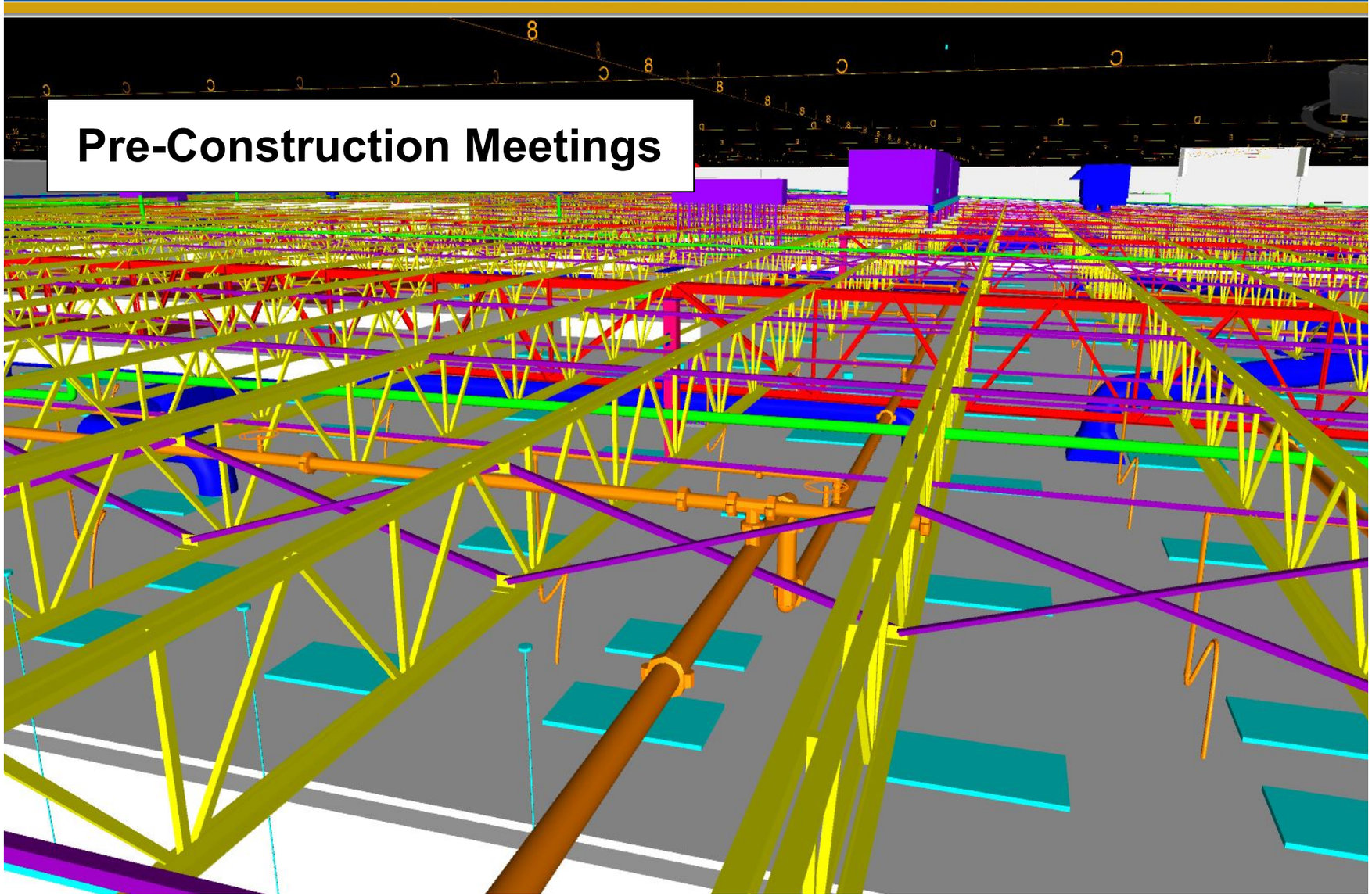
3. BIM process management



The models collected from the various trades are imported into the master BIM model. Team members from the various trades participate in an “in-model” review of the project. This virtual tour is usually accomplished through a web conference.

During the pre-construction meetings, any remaining problems are discussed and participating trades can address their issues before any construction starts. This often results in additional cost savings to the project.

Moreover, the pre-construction meetings also encourage the participants to suggest performance improvements or alternative ideas, now that the total project is coming clearly together in the BIM environment.

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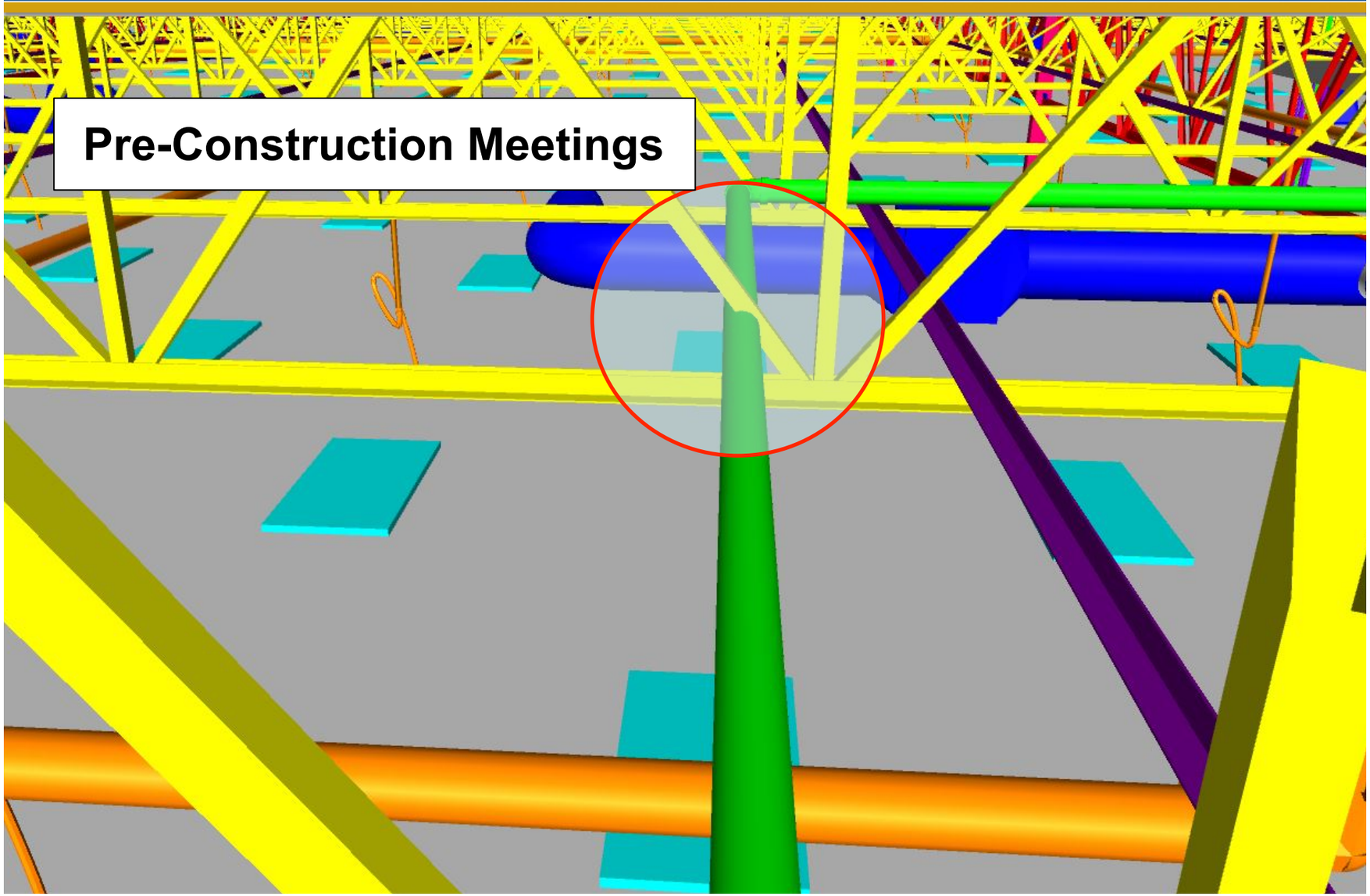
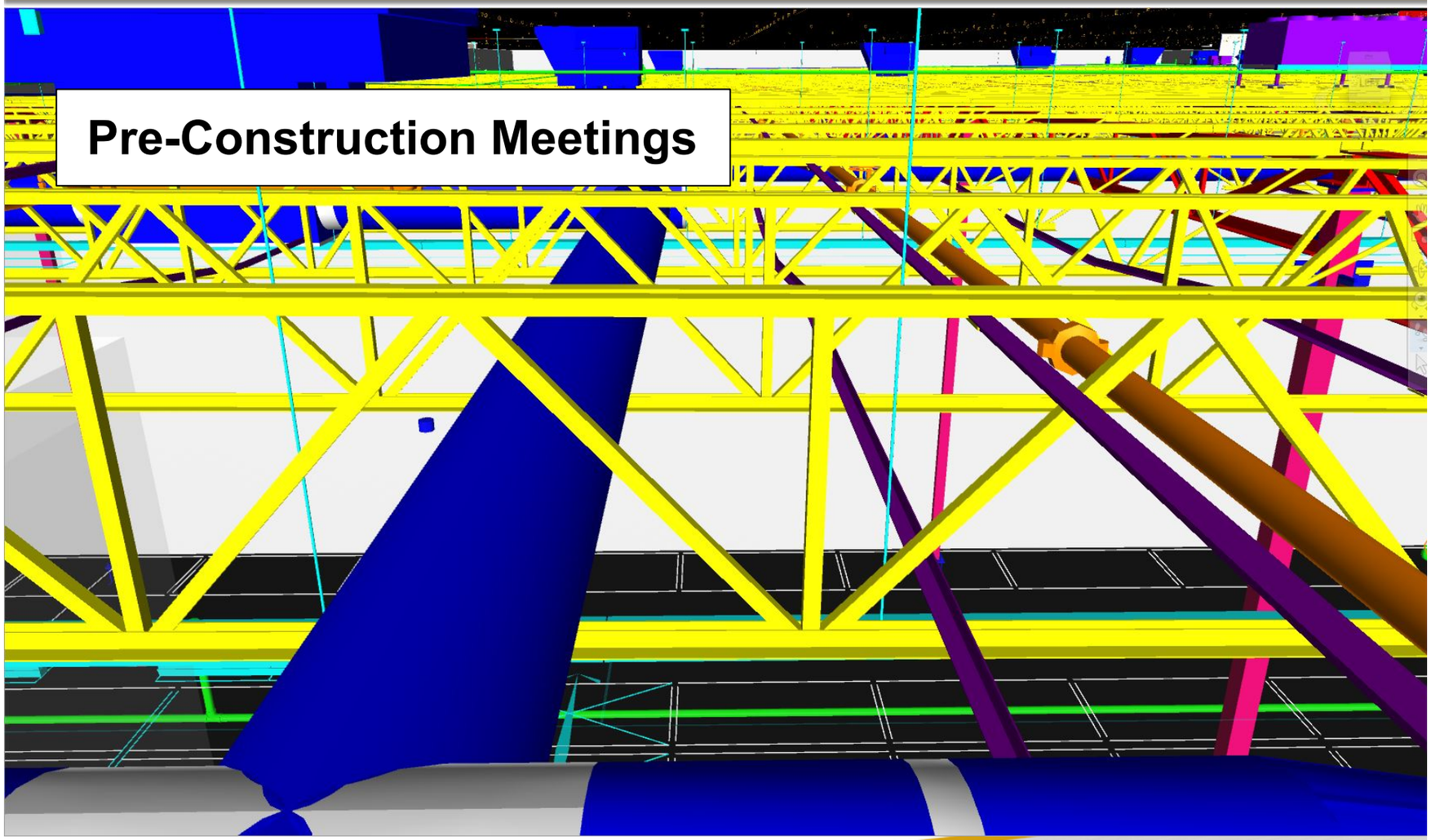
3. BIM process management



As potential crashes are identified, they are added to the list of fixes. The trades involved will quickly discuss the best approach to fix the issue. In this example, there would be a discussion concerning the clash between the pipe and joist web member. A decision would be made whether it would be more cost effective to realign the joist panel or change the path of the pipe. Both trades would weigh in to decide the least disruptive solution.

3. BIM process management



Depending on the number of issues discovered, there may be several pre-construction meetings for the project. Each trade will work on their model to correct the issues they are responsible for. Once they resolve the issue and update their model, they re-send their model to be imported in the master BIM model. The new model will then replace the previous model, in the master model, for that trade. This cycle continues, until all the issues have been resolved.

Pre-Construction Meetings

- Clashes/issues are discovered and resolved before construction begins.
- Prevents potentially costly back charges.
- Communication between trades.
  - Provides the opportunity for each trade to understand the challenges that the other trades on the project face.
  - Encourages stronger partnerships/relationships.
- Provides a powerful tool for the construction process.

As you have begun to see, BIM becomes a powerful tool for the construction process. During the pre-construction meetings, issues are discovered and resolved before construction even starts. This can prevent potential back charges as the trades communicate with each other and mutual design challenges are efficiently confronted. Trust and true design collaboration are put to work on behalf of the project owner.

Learning Objective #4

4. Collaboration and interoperability:
Proven outcomes and higher expectations for BIM-based steel joist project design.

The greater potential for BIM-based steel joist design is only beginning to be recognized within the steel construction industry. Those who have used BIM for steel joist design are reporting significant improvements in project interoperability (design information sharing), which supports improvements in total-project design collaboration.

McGraw-Hill Study

Industry-wide adoption of BIM or BIM related tools in the United States grew from 28% in 2007 to 71% in 2012.

A recent McGraw-Hill Construction study found that industry-wide adoption of BIM or BIM related tools in the United States grew from 28% in 2007 to 71% in 2012.

See: McGraw-Hill Construction Study, SmartMarketReport: The Business Value of BIM in North America, 2012 (pdf)

McGraw-Hill Study

- The frequency of model sharing between architects, engineers and contractors was more than two times higher than the frequency of model sharing between these participants and trade contractors such as steel joists, deck, and beam suppliers.

- Yet the use of BIM at the trade level was the only area where the perceived value of BIM exceeded the frequency of its use.

The study also disclosed an interesting trend regarding the frequency and perceived value of model sharing processes, specifically in regard to design collaboration at the trade level, including steel joist and deck supply: The frequency of model sharing between architects, engineers and contractors was more than two times higher than the frequency of model sharing between these participants and trade contractors such as steel joists, deck, and beam suppliers. Yet the use of BIM at the trade level was the only area where the perceived value of BIM exceeded the frequency of its use.

McGraw-Hill Study

- BIM would be the most valuable were it used in support of collaboration at the trade level. The reasons for this are as follows:
  - Reduced number and need for information requests
  - Improved communication between all parties
  - Improved accuracy of construction documents
  - Reduced field coordination problems
  - Shorter time drafting and more time designing
  - Reduced construction costs

The study further concluded that BIM would be the most valuable were it used in support of collaboration at the trade level. The reasons for this are as follows: Reduced number and need for information requests; improved communication between all parties; improved accuracy of construction documents; reduced field coordination problems; shorter time drafting and more time designing; and reduced construction costs.

Challenges

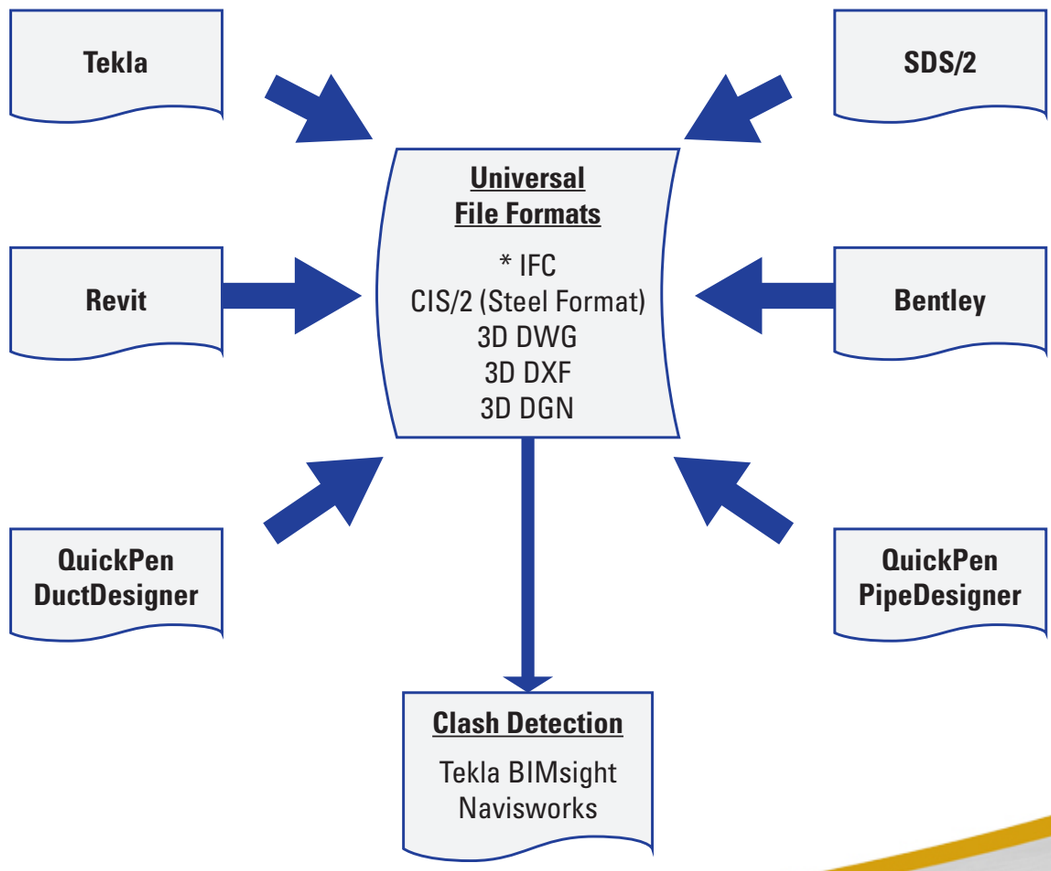
- Keeping information up-to-date between trades
- Getting all the trades to work together as one big team
- Software packages
- File Exchange

Among the challenges to BIM based collaboration is the necessary increase in communication among the participating trades to keep all information up-to-date. The coordination meetings play a big role in achieving this. The structural steel detailer and the steel joist detailer must especially communicate effectively and ongoing.

Getting all the trades to work together as one big team is another big challenge. The lines of communication must be open. The members of the team must be willing to share information. As with any team, the best results are accomplished when all the members work together. Companies can use their preferred modeling software packages, but information must still be exchanged between members of the project.

Interoperability

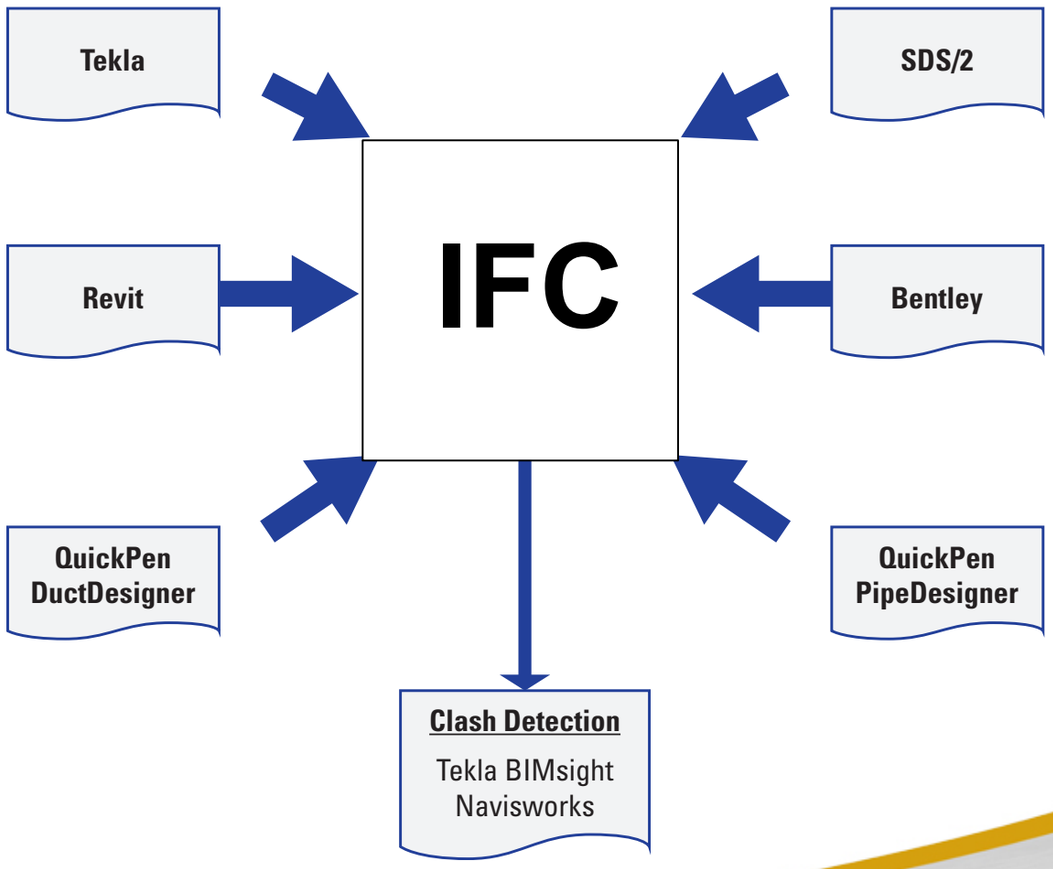
Model Integration



Interoperability is an essential function of successful BIM project development. Different brands of modeling software have entered the market and every project participant is free to choose the modeling software package that works best for their environment. So, there may be many different software packages producing models for a BIM project. In the end, those models are imported into a master BIM model, and at that point, common file formats must be used to accomplish this exchange.

Interoperability

Model Integration



The IFC model format is a common deliverable on BIM projects. Industry Foundation Classes (IFC) are the open and neutral data format for openBIM. The IFC specification is developed and maintained by buildingSMART International as its "Data standard". It is registered with ISO as ISO16739.

The IFC file format has become a widely supported format for BIM. Organizations are working together to continue improving the content of this format. In the past, the CIS/2 file format was a preferred format in the steel industry. This has changed because of the need for interoperability with other trades. The IFC model allows this.

The steel industry is now working with organizations like AISC and AISI to refine the steel standards in this file format. The IFC file format is a very reliable and stable file format.

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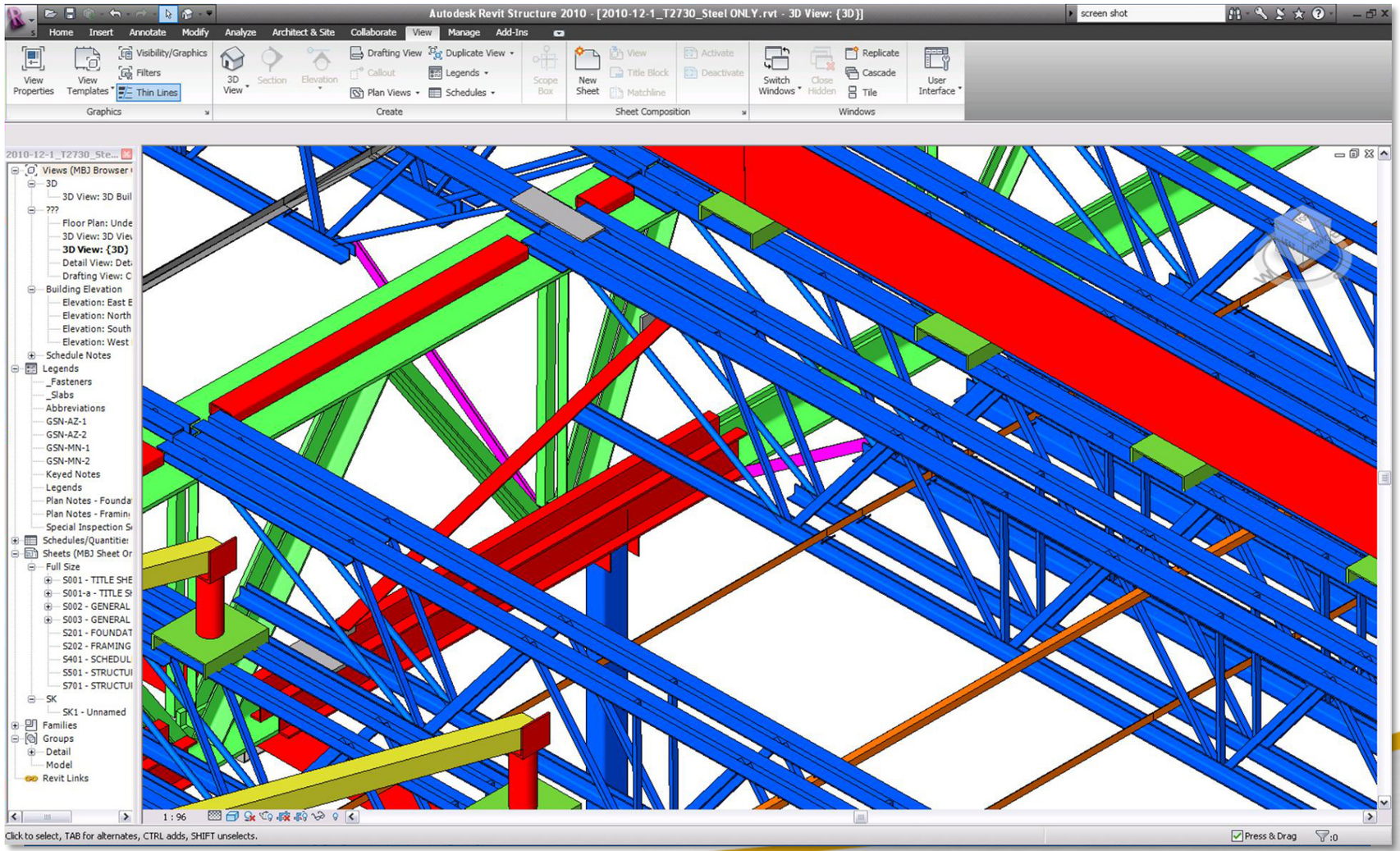
4. Collaboration: IFC



Here you see a sample of steel joists modeled in Tekla Structures imported into a Revit model.

Building a better steel experience.

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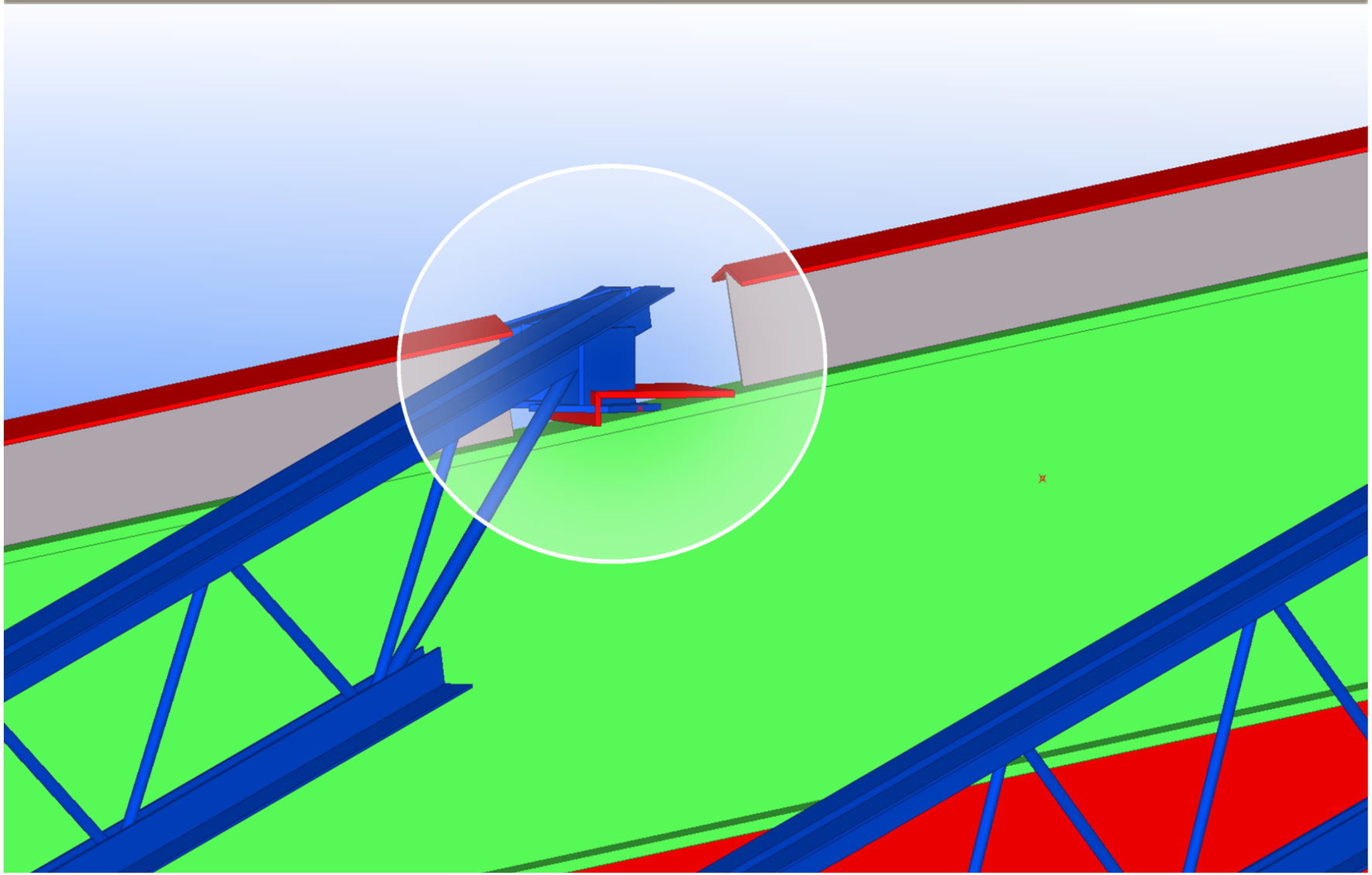
4. Collaboration: IFC

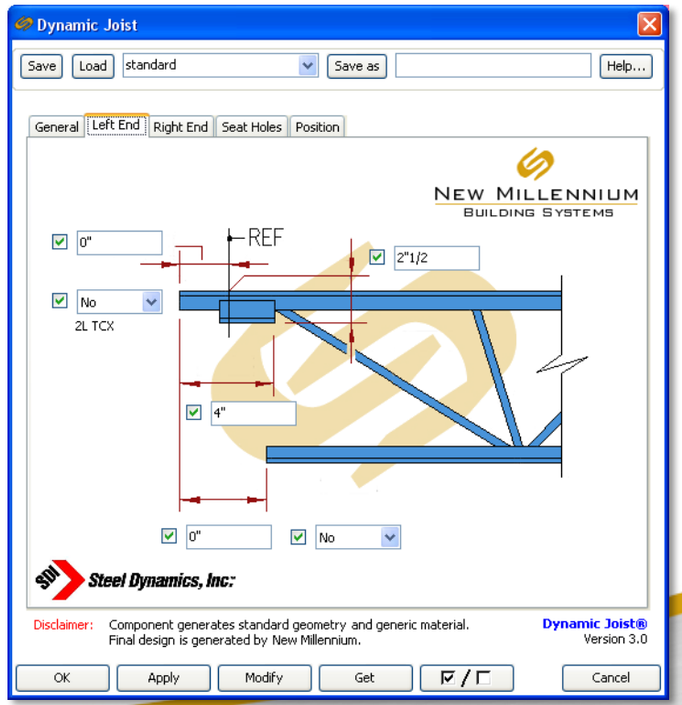


The IFC file format can be used for quick coordination as well. In the example shown here, the joist detailer was working on a difficult hip and valley design with the steel joists sitting on beams at various angles. The joist detailer was performing an in-model review with the structural engineer when they came upon this area of the design.

The engineer told the detailer that he needed to place a shim under the steel joist, but was unsure of the exact location. He asked whether the joist could be designed and an updated joist model be sent to him. This was done and an IFC file was created for sharing information on just that joist. The IFC file was sent to the engineer, who then inserted the change in his model, and positioned the shim precisely.

Goals

- Transfer as much information as possible through the model
- Provide the customer a faster turn-around
- Customer Interfaces
  - ❖ BOM Information
    - ➢ Sections
    - ➢ Loading
  - ❖ Import the information into internal systems to reduce work load and improve accuracy



As progressive trades continue to look for ways to improve the BIM process, they are especially mindful of ways to improve collaboration and interoperability. Goals for this include the transfer of as much information as possible through the model. Providing the customer a faster turn-around using BIM. Finding ways to improve the process. Giving the user the ability to enter joist-specific information in the component, such as section criteria. And the import of information into the steel joist company's internal systems to reduce workload and to improve accuracy.

Goals

- Improved communication
  - Updating model information between joist and steel detailers
    - Provides better visualization
    - Supports/enables better design
- Give customers an even better understanding of the BIM process
- Provide owners a virtual vision of the components in their building

Additional goals include improved communication; keeping models updated between the joist and steel detailer provides a better visualization, as well as supporting a better project design; educating others to foster a better understanding of the steel joist BIM process; and providing project owners with a virtual but dimensionally true vision of the joist components in their building, for subsequent building management uses.

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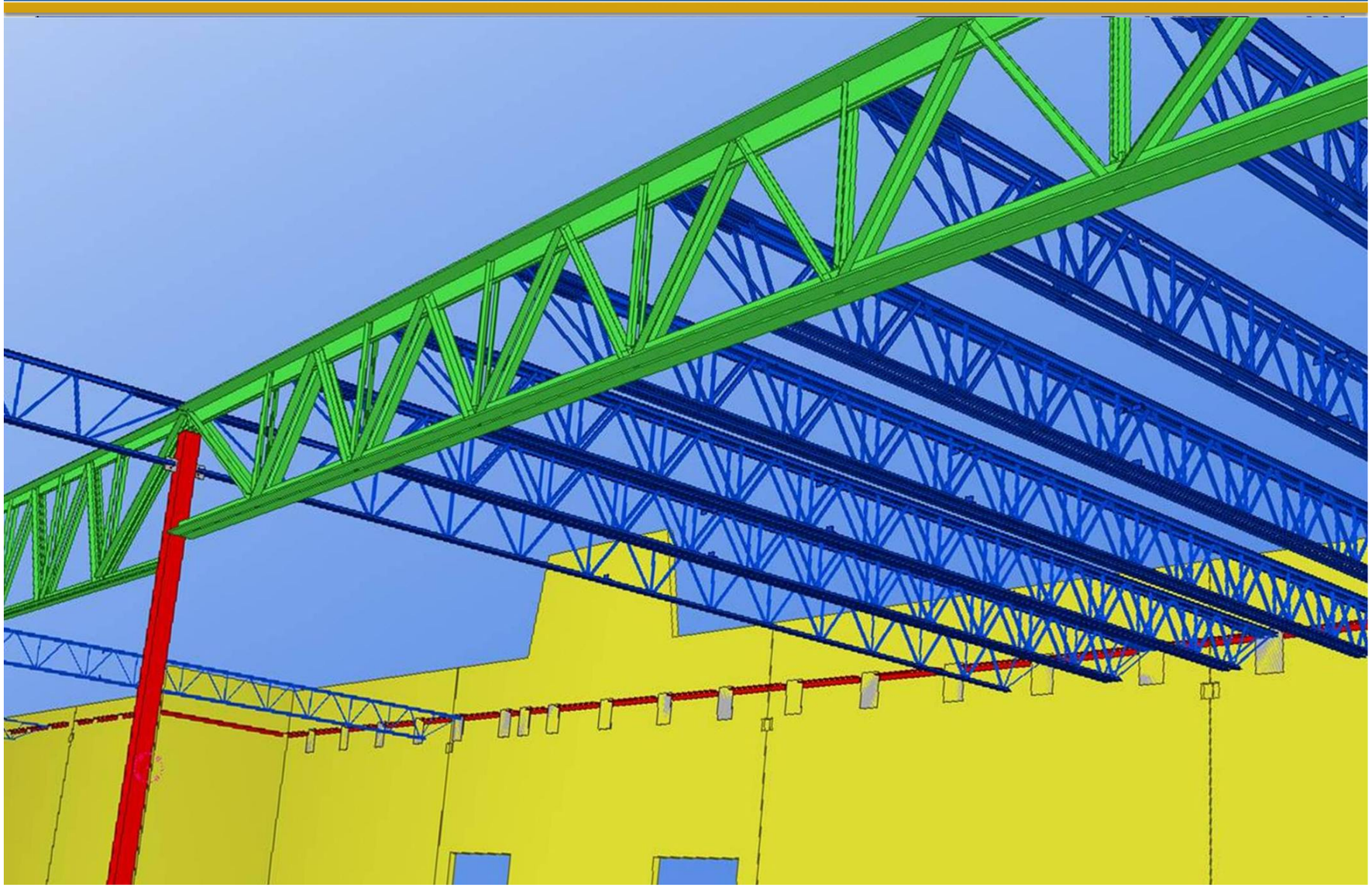
Conclusion



In conclusion, BIM is more that just 3D modeling. It's about supporting the overall team concept with better collaboration and coordination. It is a way of forming strong partnerships and building trust that benefits the project and brings out the best efforts of project participants. Most of all, BIM is a way to better serve the cost and performance expectations of the building owner. All by turning virtual design into reality.