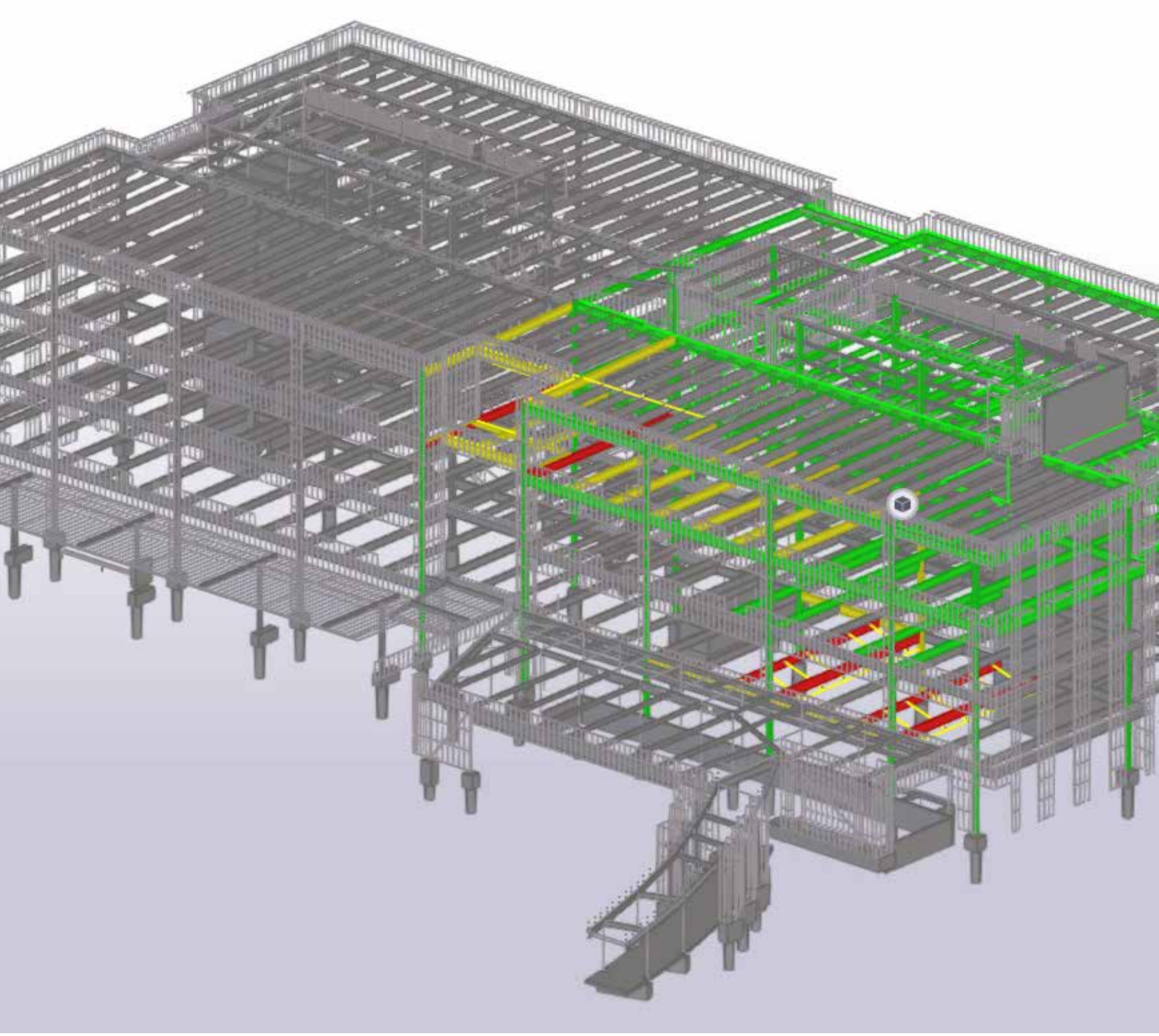

Model Review and Approval

for Structural Steel

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Stronger.
Steel.

by

American Institute of Steel Construction

Printed in the United States of America

Model Review and Approval for Structural Steel

Foreward

AISC has prepared this guide to introduce and clarification of the process of digital model review and approval as an alternative to the traditional process of reviewing and approving *shop* and *erection drawings*. This document is not intended to provide a comprehensive or contractual outline for model review and approval practices. Rather, it is a best practice guideline for what you may encounter with this evolving process within the building industry.

Be aware that this printed document may not contain the most recent information. Visit **aisc.org/modelreviewguide** for the latest developments.

Acknowledgments

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Introduction

Historically, the AEC industry has used *shop* and *erection drawings* to translate the owner's *design documents* into a suitable format for fabrication and construction. In the structural steel industry, this entailed re-drafting or re-modeling the structural engineer's 2D drawings to include the specific and detailed information necessary for the fabrication and erection of each and every piece. The detailer then created new 2D drawings, commonly referred to as *shop* and *erection drawings*, and submitted them to the design team to review and approve in order to confirm that the detailer properly interpreted the structural engineer's design for the fabrication and erection of the steel.

Over time, this process has not changed much. Emailed PDFs have replaced courier or mail delivery of multiple paper copies of *shop drawings*, each with hand-copied review comments. This has saved time, but the process remains fundamentally the same: an iterative, disconnected process focused on successive versions of 2D drawings.

However, this is beginning to change. A new process, called model review and approval, has emerged in recent years—and it could revolutionize the submittal review process by keeping both the design team and the construction team in the 3D realm to more closely mirror the actual constructed world. Model review offers many advantages over review of traditional 2D drawings, including better quality and increased efficiency.

Benefits of Model Review and Approval

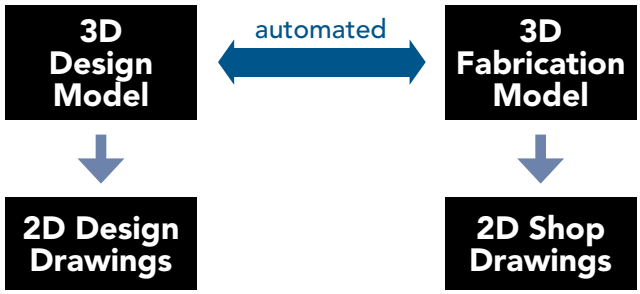
Old Method

As mentioned above, the model review process addresses many of the challenges of the repetitive and disconnected traditional process. The primary benefits are outlined below.

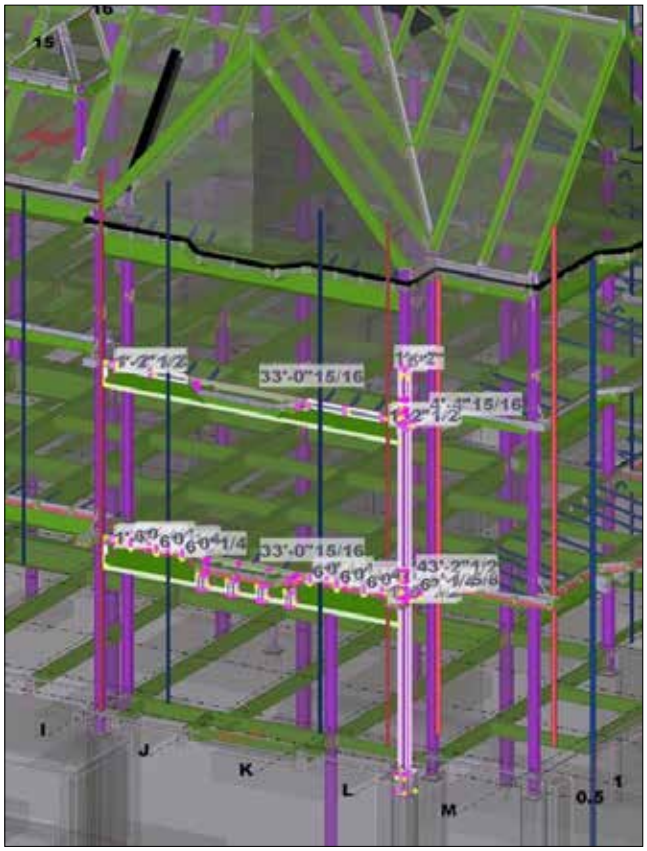
Reduced translation errors

Fabricating and constructing buildings and bridges in the real world is, of course, a decidedly 3D activity. The process of flattening the designs to create abstract 2D drawings introduces an opportunity for errors and misinterpretation. Adjusting the approach from the old methods to the new method allows for the shared 3D model to be used for all steps of the process—detailing, review, approval, fabrication, and erection and reduces the likelihood of translation errors.

New Method



The clarity of a beam-column joint shown in model vs. multiple 2D documents



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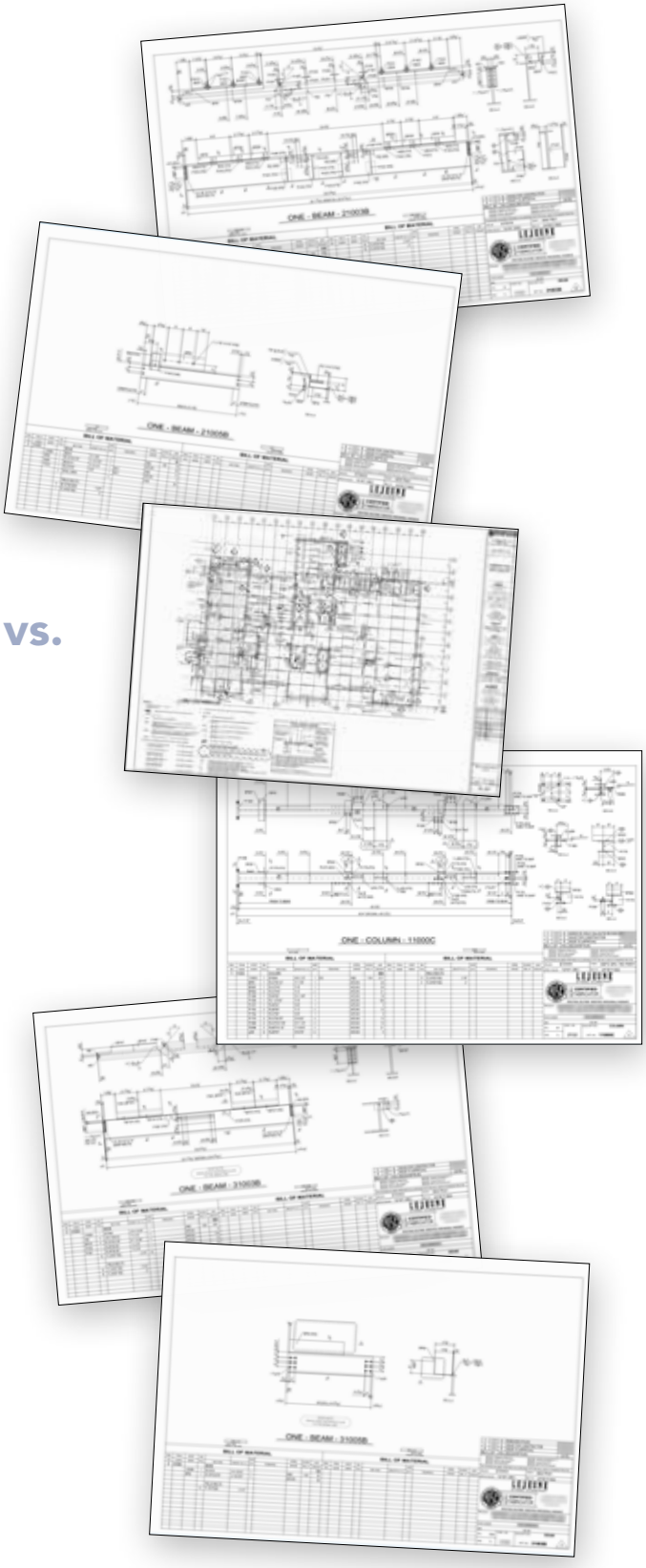
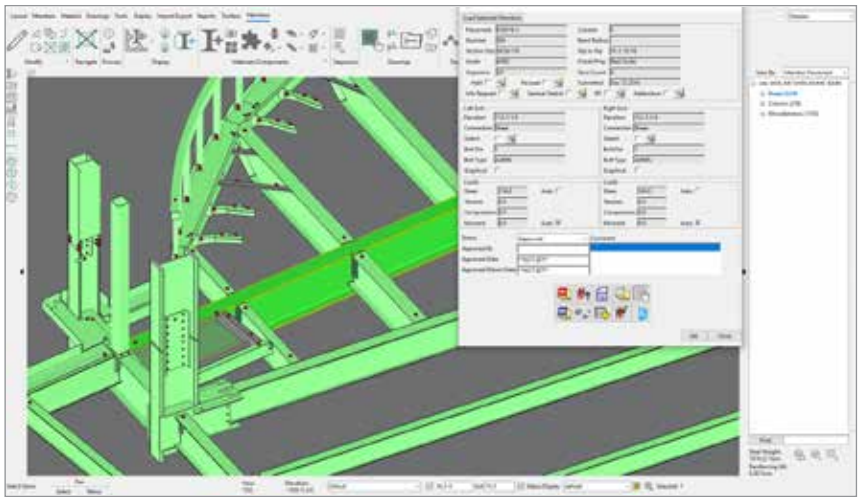


Better understanding

It is much easier to conceptualize and understand a 3D structure with one 3D model instead of trying to assemble multiple 2D images to form a complete picture.

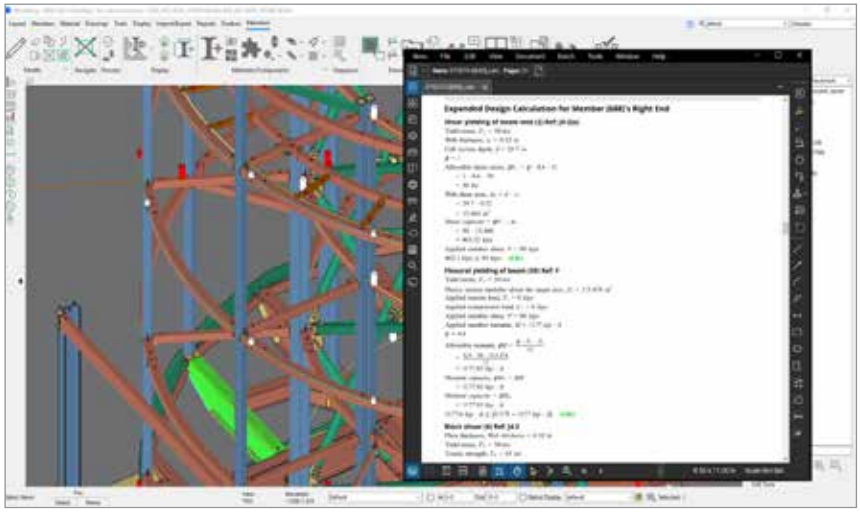
Take, for example, the review of a typical beam-column joint on the interior of a multi-story building. In the traditional 2D shop drawing approach, the team must consult at least six documents: the erection plan (for the piece numbers) and a total of five piece drawings (one for the column and each of the beams on all four sides). The reviewer will likely need to flip back and forth between these six drawings during the process, too.

In a model review approach, piece numbers are irrelevant and those same five members can be reviewed together at one time, with the reviewer easily navigating around the joint in a 3D model to accurately evaluate not just the member size and location but also typical concerns such as proper elevations, connection piece alignment, interference from elements such as stiffeners and kickers, and coordination with miscellaneous elements like deck support angles.



Leveraging metadata

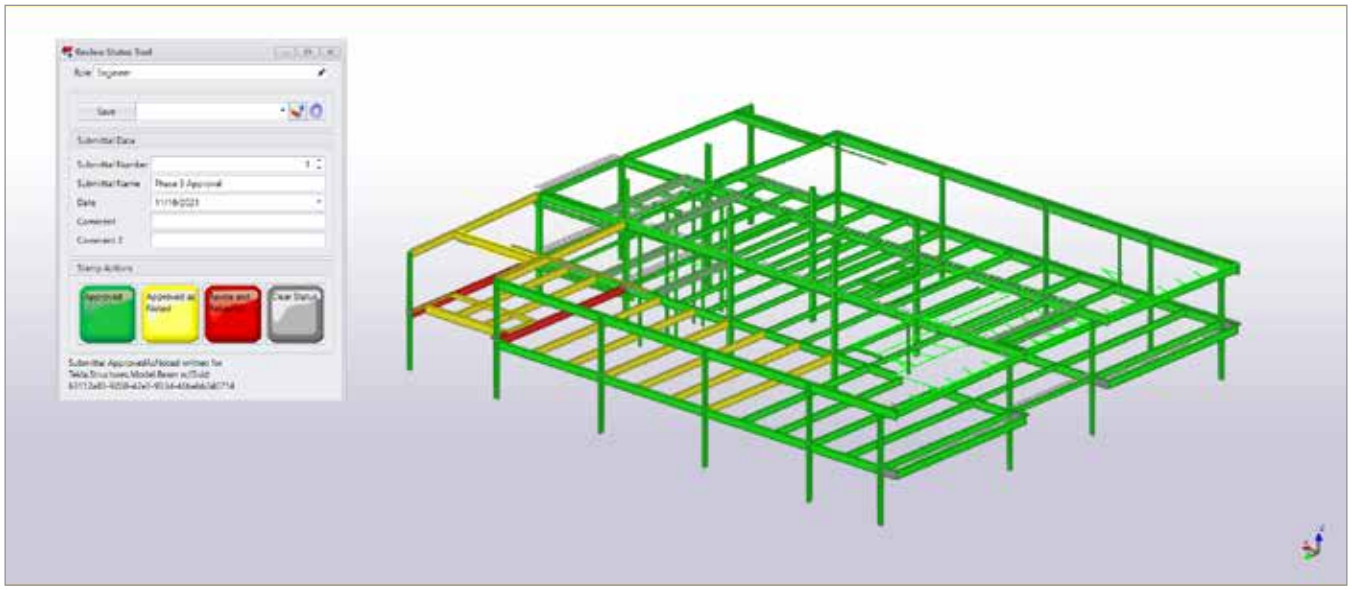
It is easier to review non-physical design elements in a model review process, too. Traditionally, criteria like hot-dipped galvanizing and architecturally exposed structural steel (AESS) categories would be simply noted (and occasionally lost) in text on 2D piece drawings. With a 3D model, fabricators can incorporate metadata fields into each modeled element or assembly, and reviewers can simply filter the view for a particular metadata field to isolate only what they are looking for, ensuring that nothing is missed.

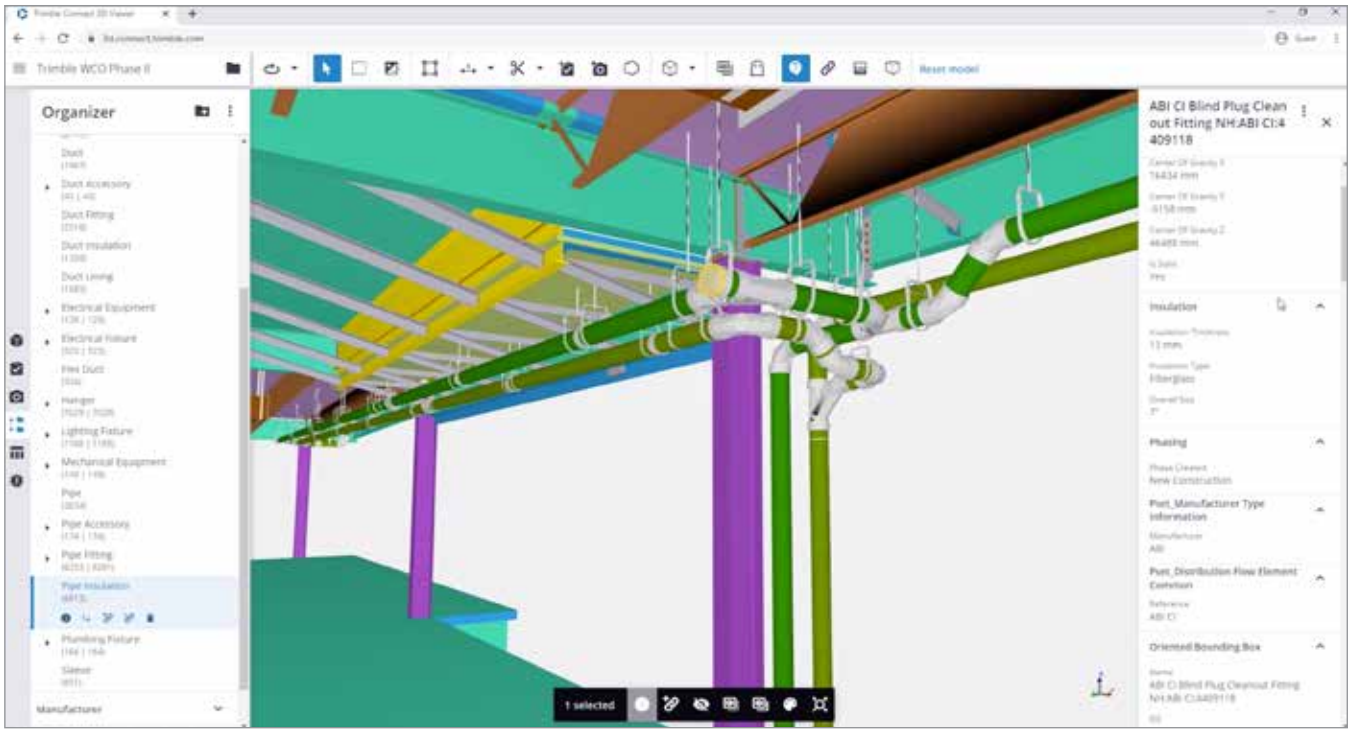


Clearer review status

With traditional 2D *shop* and *erection drawings*, conveying the submittal review action of the individual sheets (let alone the individual pieces and assemblies) is a monumental task in and of itself—and it can be downright impossible to track the status of missing elements.

However, with model review, the review action is recorded and tracked for each assembly, thereby removing any ambiguity with the design team's review or the status of a given assembly. The fabricator can release assemblies as they are approved while revising and resubmitting only those that need correction.





Enhanced access for the whole team

As today's buildings become increasingly complex, contractors are embracing a BIM workflow for their teams, too. The model review process allows design and construction teams to more directly involve the steel fabricator in this workflow.

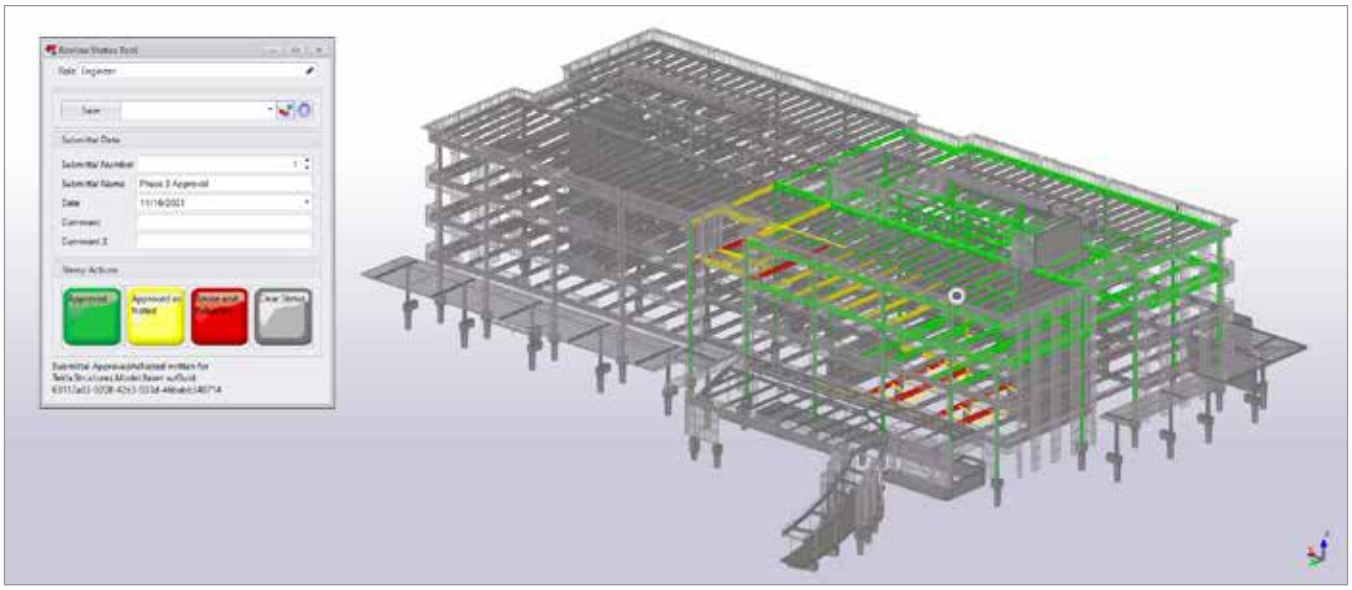
In addition, other members of the design team beyond the structural engineer may need to review and act on the structural steel submittals. For instance, architects may want to review slab openings or façade attachments, and mechanical engineers may want to review equipment supports. The model review process allows all design team members to access and review the structural steel *fabrication model* simultaneously while using their individual discipline design models. This is especially important on fast-tracked projects where disciplines are completing their designs out of sync with each other but in coordination with the detailed structural steel.

For the construction team, the detailed structural steel model helps coordinate with other trades. For instance, pipes and valves can be easily oriented to avoid obstruction from a steel kicker, and construction managers and general contractors may have the option to look up information about fabrication and shipment status in the *fabrication model's* metadata.

Quality and efficiency improvements

Taken together, the improvements which model review and approval offer over traditional submittal review mean more than simple process efficiency. Once you get comfortable with the model review software and establish an implementation and approach, you may see opportunities to streamline or enhance many facets of a project.

As with any new process, project teams should not expect to "plug and play" type success with model review and approval. To enjoy the benefits, teams will need patience with the learning curve and a willingness to fail on occasion. Additionally, teams should set goals and expectations and prepare for some level of discomfort. See the "Factors for Success" section on p.13.



For example: Can the design team go deeper into the review of the model with the new process? Does the design team require fewer staff members during this phase? Can the construction schedule be reduced? Can some of the review steps be automated by leveraging metadata? Are additional checks for "model metadata completeness" required before a review can begin?

Now what?

The rest of this guide will address specific considerations to help you implement a model review process for your projects.

Is Model Review and Approval Legal?

What does the *Code* say?

There are multiple relevant sections in the *Code of Standard Practice for Steel Buildings and Bridges* (AISC 303-16). The *Code* does not establish a preference between 2D drawings and 3D models as *approval documents*. Either is acceptable as long as all parties agree.

- Section 1.4 of the *Code* describes the allowable use of both models and 2D drawings as contract documents but it does not specify which take precedence. This means that the owner's designated representative for design should explicitly define the contract documents as well as which documents should take precedence in the event of conflicting information. This allows for variation in practice within the industry; a BIM Execution Plan should be developed for each project to establish protocol and determine whether the approval process will use models, drawings, or a combination thereof.
- Section 4.2.3 stipulates that *fabrication* and *erection models* should be uniquely identified when they are used as *approval documents*.
- Section 4.4 stipulates that whatever the approval documents consist of, they shall be submitted to the owner's designated representatives for approval.

What does your company say?

Reviewing a 3D model improves both the quality and efficiency of the process, but there can be a learning curve, just as with anything new.

Individual companies will have varying policies on model approval, depending on their own levels of comfort, experience, and capability. Although it is relatively easy to implement model review and approval processes, companies should not do so lightly or without forethought, training, and some practice runs.

It is worth it, though. Once you get comfortable with the model review software and establish an implementation and approach that you are comfortable with, you can expect a model review process to proceed more quickly than traditional submittal review processes. You will get a sense of how much time you should schedule for this phase—and you may even need fewer staff members to do it.

Workflow Using the 3D Fabrication Model

Typically, the structural assemblies—that is, primary framing and connection parts—are reviewed for compliance at three levels:

- within the context of other building systems;
- within the context of other structural assemblies and structural systems, and;
- within their own structural assembly.

Each of these investigations involves a separate review of several design parameters, like geometry and section and material properties. Checking each of these parameters can be a tedious process, but 3D modeling programs include tools that can speed this up dramatically.

The information that was traditionally checked on *shop* and *erection drawings*—member sizes, lengths, locations, grades of material, welds, bolts, hole sizes, etc.—can, of course, also be checked in the 3D *fabrication model*—and in almost all cases, that model is precisely what will drive the fabrication. Some fabricators will export instructions for fabrication equipment straight from the model, which eliminates potential errors translating the data from drawings to instructions for fabrication and welding machines. It is therefore absolutely critical that the approved model be accurate and correct, particularly as more fabricators adopt robotic systems. Design teams should determine protocols and/or checklists to verify that the fabricator's model properly reflects the structural design intent.

That said, some 2D drawings or information could be useful supplements to the 3D model during the review process. Many software packages allow teams to link drawings, sketches, and other documents to an assembly to provide additional context for the model review and approval process. Some software also allows users to overlay 2D annotations (marks, notes, dimensions, etc.) in the 3D model. After all, *shop* and *erection drawings* are primarily intended to communicate instructions to build structures. A model review workflow simply makes that process more efficient.

Role of early communication

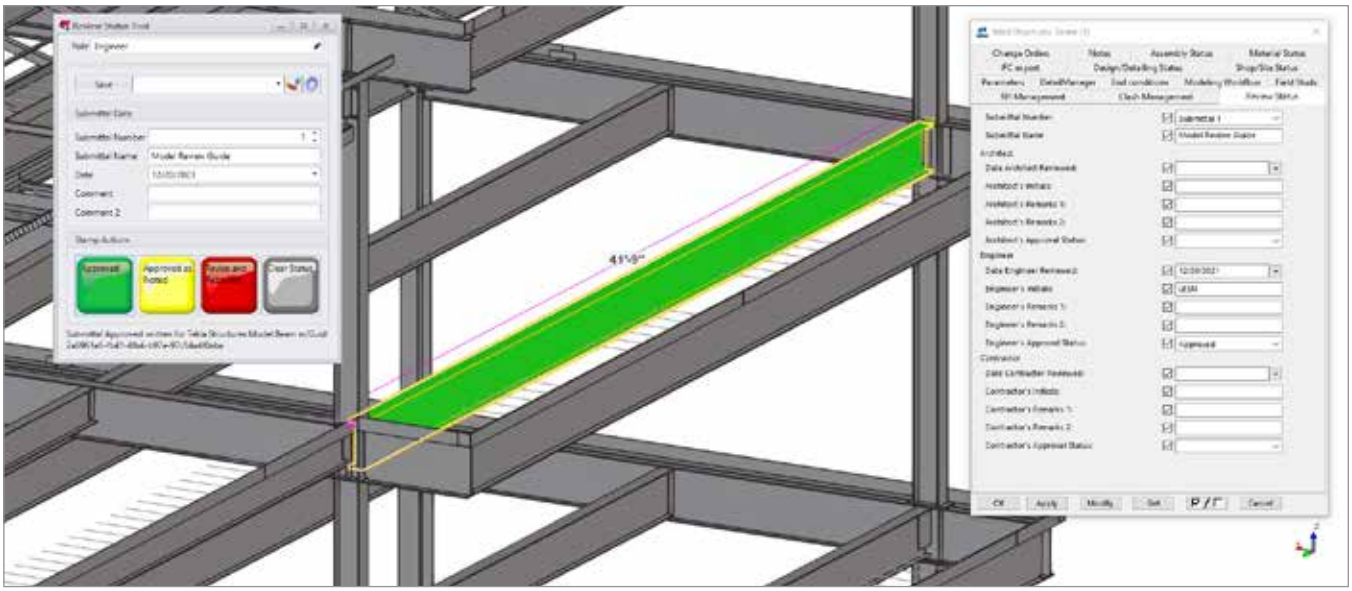
The key to a successful 3D model review and approval workflow is early communication with the project team. A pre-coordination meeting of the owner's representative, steel contractor (detailer and/or fabricator), structural engineer, and general contractors can determine any necessary adjustments to their individual workflows to avoid time-consuming confusion later in the process.

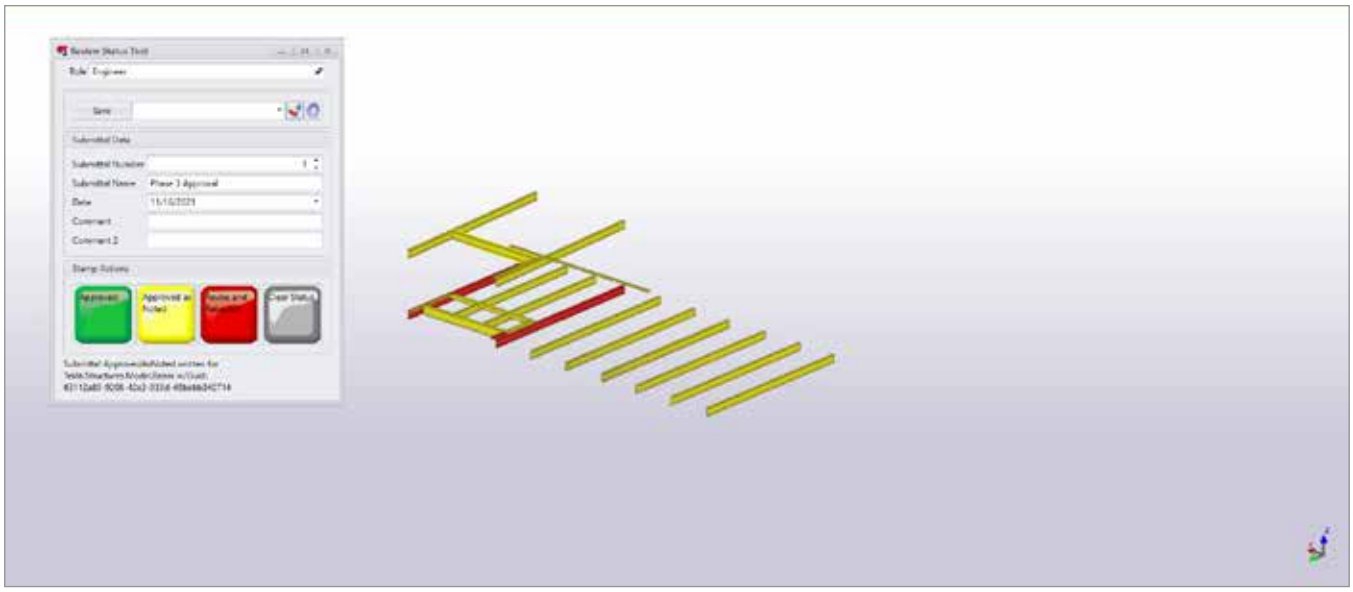
These early meetings should establish protocols for things like:

- Review comments
- Submittal actions
- Model updates and resubmittals

Review comments

Comments can be stored and associated with a variety of elements of the model. It is critical that every member of the team knows where to leave and find the latest comments. (Remember, in this process, a comment could include a 2D sketch or additional non-text information.) Establishing a standard location for comments can save a lot of time and confusion later in the process and create crucial transparency between, for instance, the fabrication shop and erector.





Submittal review action and communication protocols

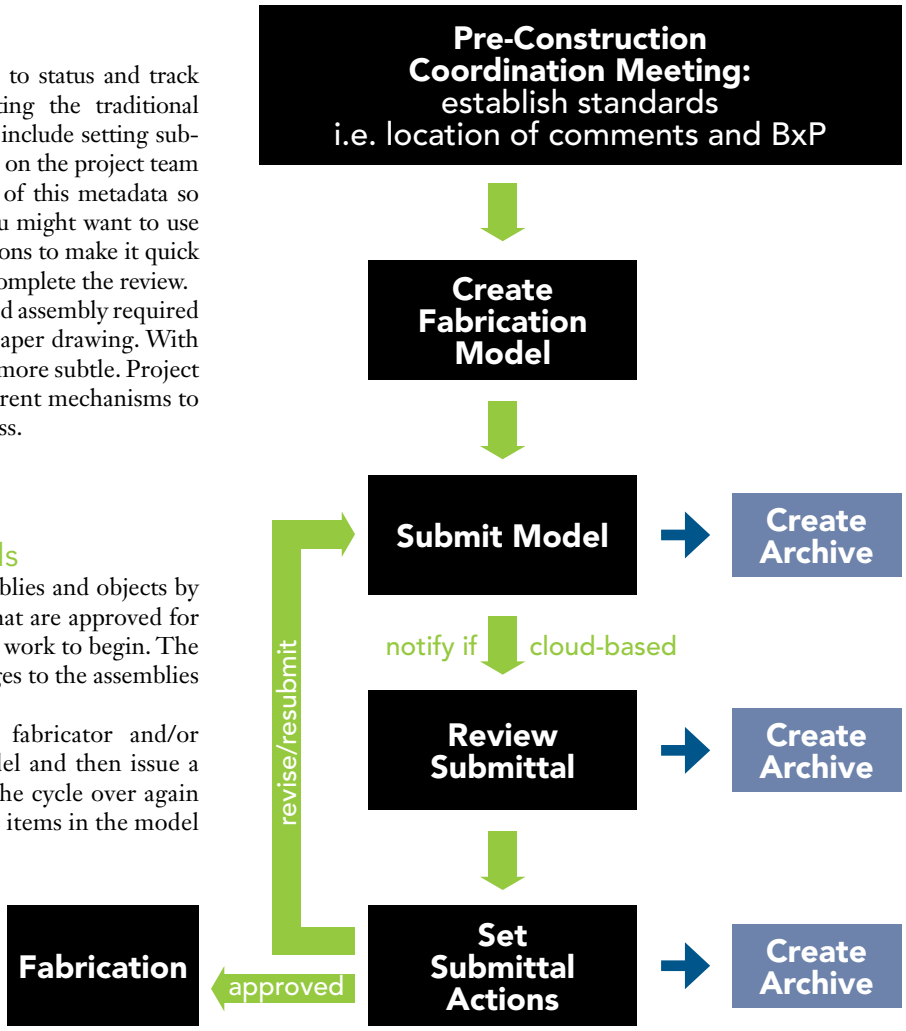
Most modeling applications have a method to status and track user-defined attributes—essentially replicating the traditional review stamp on a 2D drawing. This would include setting submittal review actions per assembly. Everyone on the project team should understand the format and location of this metadata so anyone can easily check review progress. You might want to use colored labels for these submittal review actions to make it quick and easy to see what remains to be done to complete the review.

It used to be easy to know when a reviewed assembly required your attention—someone would deliver a paper drawing. With a digital workflow, notifications can be a lot more subtle. Project teams should also develop standard, transparent mechanisms to keep all members apprised of review progress.

Model updates and resubmittals

Model software makes it easy to sort assemblies and objects by review status. For example, all assemblies that are approved for fabrication can be sent to the shop allowing work to begin. The detailer can then focus on making the changes to the assemblies that need to be revised.

If the model requires revision, the fabricator and/or detailer will make the changes to the model and then issue a new version of the model. This will start the cycle over again where the design team reviews the updated items in the model reissued for approval.



Model Data

In a model review and approval workflow, the model itself is the primary data source at the root of all communication. The better the communication and its understanding, the better the results.

In the early phases of a project, the different model elements may not have consistent levels of development (LOD), or extent to which it has been fully fleshed-out. Instead, each element may have its own LOD. Assemblies will generally be developed enough for fabrication (described as having an LOD of 400) when they are released for approval, but do not assume that is the case. There may still be outstanding information or detailer assumptions that need to be verified.

Everyone on the project team should know where to look for the digital equivalent of the familiar "engineer, please verify" note on *shop drawings*. Your model could indicate this with color coding, or by isolating the assemblies in question to help the reviewer concentrate only on the items that need further attention. (Software packages frequently offer tools that allow users to filter model objects to only show the assemblies set for review.) Again, communication is critical so everyone involved knows where quickly and easily to find this information in the model, as well as additional information about those specific assemblies (which could include references to sketches, revised areas, design sketches, 2D fabrication images, and more).

The BIMForum LOD specification (**bimforum.org/lod/**) has further details about LOD, including the difference between level of development and level of detail.

The *Level of Development (LOD) Specification* is a reference that enables practitioners in the AEC Industry to specify and articulate with a high level of clarity the content and reliability of Building Information Models (BIMs) at various stages in the design and construction process. This clear articulation allows model authors to define what their models can be relied on for, and allows downstream users to clearly understand the usability and the limitations of models they are receiving. It does not prescribe what Levels of Development are to be reached at what point in a project but leaves the specification of the model progression to the user of this document.

Deliverables and storage

Whether the digital model files are stored locally or in the cloud, they must be accessible to all firms involved. And, as with any electronic file management, it is impossible to overstate the importance of consistent, reliable backups with offsite file redundancy wherever possible.

As with all aspects of model review and approval workflows, communication at the outset is critical. All parties should agree to and be aware of not only where the model is stored but also file naming conventions. Having this setup early in the process can avoid confusion and disputes.

As previously noted, the detection of conflicts in the model are generally handled in the BIM coordination (federated or collaborative) model, but it can be advantageous to have the architectural, and mechanical elements available in the model to assist the engineer and architect in the review process. The necessity of such elements in the structural model should be settled early on in the contractual agreement. The design team will need to not only have the model, but all supporting data. As stated earlier, having this data attached to the model will make the process even more efficient, instead of having to search a separate data location.

Fabricators may choose to send the entire model for review, or only send the portion to be reviewed with connecting assemblies. It is suggested that if only a portion of the model is to be sent for review, that previously reviewed sections are included as well. There are some that have ventured into the cloud based model review which has opened a whole new realm of possibilities of real-time communication, eliminating the need to transfer and store large models, but this process does require certain safeguards to protect the integrity of what has been reviewed.

Every firm involved in the project should also use the same software, preferably the package used to author the original model, to avoid any data loss from potential compatibility issues between the native application and third-party software. (Standardized file formats currently in development, such as IFC, should minimize this problem in the future.) Early discussions should discuss software requirements and resolve concerns about additional costs related to training and the software itself.

Version tracking

Models are designed to evolve as they go through the review process, but it can be useful to have snapshots of the files at various stages (particularly in case of litigation). Software packages provide a few ways to do this.

Most fabrication software will export an IFC file that includes all notes that, when packaged with any supporting data, will provide sufficient protection while taking up less storage space than a full copy of the model. You can also configure an automated, aggregated report that serves as a kind of cover sheet for submittal returns; these reports can include the reviewed assembly, the reviewer, the status, and references to drawings with mark-ups or other notes.

For the submittal return, you may want to have some kind of automated, aggregated report that contains the reviewed assembly, the reviewer, the submittal review action as well as any reference to drawings with mark-ups or any other notes. This acts as a cover sheet to the submittal, which can also have an electronic stamp.

Factors for success

As discussed within this Guide, model review and approval offers the structural steel industry many advantages over the traditional 2D shop drawing review process. As you being, we offer the following tips for success:

- Forget "Business as Usual." Model review and approval is a new process, embrace it for what it offers, and don't force it to be just like the old process.
- Build a team that is excited about doing this. People who are excited find ways to overcome challenges and create success.
- Establish reasonable expectations. Plan, communicate the plan, stick to the plan.
- Periodic check-ins and corrections. Nothing goes as planned the first time, but allow yourself periodic check-ins with your teams and make corrections from what you hear
- Train, then re-train. At the first training session, you won't know what you don't know. Plan a refresher training after the first few submittals to refresh on software picks and clicks, share success on individual process, and update what's not working.
- Ensure plenty of computing power and Internet speed. This is a technology enabled process. Making sure you have enough bandwidth and processing power will avoid frustration.

Note: Terms designated with italics are taken directly from The *Code of Standard Practice for Steel Buildings and Bridges* (AISC 303-16).

Approval documents
The structural steel shop drawings, erection drawings, and embedment drawings, or where the parties have agreed in the contract documents to provide digital model(s), the fabrication and erection models. A combination of drawings and digital models also may be provided.

Assembly
Steel parts joined together by shop welds or bolts. For example, a beam with attachments, such as a perimeter bent plate and headed studs, that are shop-welded or bolted to it would be considered a single assembly.

The *Code*
The AISC *Code of Standard Practice for Steel Buildings and Bridges* (AISC 303-16).

Design team
The entities responsible to the owner for the overall design of the project. Can include the structural engineer of record, the architect of record, and others responsible for structural steel review.

Erection drawings
Field-installation or member-placement drawings that are prepared by the fabricator to show the location and attachment of the individual structural steel shipping pieces.

Erection model
A dimensionally accurate 3D digital model produced to convey the information necessary to erect the structural steel. This may be the same digital model as the fabrication model, but it is not required to be.

Fabrication model
A dimensionally accurate 3D digital model produced to convey the information necessary to fabricate the structural steel. This may be the same digital model as the erection model, but it is not required to be.

Levels of Development (LOD)
The Level of Development (LOD) Specification is a reference tool intended to improve the quality of communication among users of Building Information Models (BIMs) LOD is sometimes interpreted as Level of Detail rather than Level of Development. With in the context of this guide, it refers to Levels of Development.

Metadata
A subset of data that provides context about the main data or files in the model. This can include file size, date last modified, question fields as well as technical data such as whether a member is galvanized or its AESS category.

Native format/natively
The file format(s) that a specific software package is primarily designed to generate and modify. For instance, Microsoft Word's native file formats are .doc and .docx.

Shop drawings
Drawings of the individual structural steel shipping pieces that are to be produced in a fabrication shop.

Submittal review action
In general accordance with the *Code* Section 4.4, it is the design team's approval action of the submitted *approval documents*. A project's specific action terms and their explanation (e.g. Approved, Approved as Noted, Revise and Resubmit, Rejected, Reviewed for Information Only) are typically defined in the project's specifications (e.g. AIA *MasterSpec* Section 01 33 00 Submittal Procedures).

APPENDIX 1 –
Commentary on AIA *MasterSpec*

As project teams, firms, and individuals look to move into a model review and approval workflow, successful implementation relies on well-defined, mutually understood process details. Laying out these shared expectations and vocabulary in the project's specifications can smooth the transition to model review and approval within the familiar existing governance framework of traditional 2D submittal review and approval. These requirements can then be incorporated and expanded into other downstream project agreements such as contracts, subcontracts, and BIM Execution Plans.

The following commentary on select AIA *MasterSpec* sections identifies topics to consider when incorporating model review and approval into a project.

Section 013100 – Project Management and Coordination (09/19)

New Part 1 Article "Coordination Models" before Article "Coordination Drawings"
- Add requirements for Coordination Models according to the requirement in individual specification sections. Include the use and incorporation of fabrication and erection models, items to be modeled (including non-physical items such as clearance zones and erection paths), metadata, etc.

Article 1.6 – Coordination Drawings
- Delete Article or revise to address primacy of coordination models.

Article 1.8 – Digital Project Management Procedures
- Paragraph B – Use of Architect's Digital Data Files
  - Subparagraph 1 – Revise permissible uses to include preparing coordination models, fabrication models, and erection models.

Article 1.9 – Project Meetings
- Paragraph E – Project Closeout Conference
  - Subparagraph 3.a – Revise subparagraph to include discussion of record models such as "Preparation of Record Documents and Models."

Section 013300 – Submittal Procedures (03/21)

Article 1.2 – Definitions
- Paragraph A – Action Submittals: Revise definition to include modeled information such as "Written, modeled, and graphic information…"
- Paragraph B – Informational Submittals: Revise definition to include modeled information such as "Written, modeled, and graphic information…"

Article 1.4 – Submittal Formats
- Paragraph A – Submittal Information: Add requirements addressing how this information is to be conveyed for model submittals.
- Paragraph B – Options: Add requirements addressing the identification of options within the model. One possible approach is through the use of parameters and metadata on each modeled element or assembly.
- Paragraph C – Deviations and Additional Information: Add requirements to define how deviations will be identified and questions to the approver will be asked within the model. One possible approach is through the use of parameters and metadata on each modeled element or assembly.
- Add new paragraph "Model Submittals" and subparagraphs indicating the general requirements for model submittals such as format, hosting platform, transmission methodology (for partial model submittals), notification methodology (for cloud-based whole models), licensing fees, etc.

Article 1.5 – Submittal Procedures
- Paragraph A – "Prepare and submit…":
  - Add new "Models" subparagraph indicating the requirements for preparation and submission of model based submittals.
- Paragraph D – Resubmittals: Add requirements for model resubmission. Address topics such as the tracking and identification of revisions and identification of model elements or assemblies being resubmitted. One possible approach is through the use of parameters and metadata on each modeled element or assembly.
- Paragraph E – Distribution: Add requirements for the distribution of approved models. Address the model availability for use by other parties, including licensing and security issues, or if 2D drawings will be created from the model, bearing the approval comments and submittal review action status for use by other parties.
- Paragraph F – Use for Construction: Add requirements for the use of approved models. Address the model availability for use by other parties, including licensing and security issues, or if 2D drawings will be created from the model, bearing the approval comments and final submittal review action, for construction use on the Project site.

Article 1.6 – Submittal Requirements
- Paragraph B – Shop Drawings
  - Subparagraph 3 – BIM Incorporation: Add requirements to address the creation of 2D drawings from a model.
- Add new paragraph "Models" and subparagraphs indicating the general requirements for models including overarching metadata, coordinate systems and orientation, etc.

Article 1.7 – Delegated Design Services
- Paragraph B – Delegated Design Services Certification: Revise to include model submittals such as "In addition to Shop Drawings, Models, Product Data, and other required submittals…"
- Paragraph C – BIM Incorporation: Add requirements addressing how delegated design information is to be included into or referenced from models submitted for review and approval.

Article 1.8 – Contractor's Review
- Paragraph A – Action Submittals and Informational Submittals: Include requirements to address the manner of Contractor's review of the model and/or modeled elements and how Contractor's Approval will be marked on the model.

Article 1.9 – Architect's [and Construction Manager's] Review
- Paragraph A – Action Submittals
  - Add new subparagraph "Model Submittals" addressing how models and modeled elements or assemblies will be marked to convey the submittal review action. One possible approach is through the use of parameters and metadata on each modeled element or assembly.
- Paragraph E – Add requirements addressing how model submittals received from sources other than Contractor, such as cloud-hosted models or those transmitted directly from the detailer, will be addressed.

Section 017839 – Project Record Documents (12/18)

Article 1.2 – Summary
- Paragraph A – "Section includes…"
  - Add new subparagraph "Record models."

Article 1.3 – Closeout Submittals
- Add new paragraph "Record Models" and subparagraphs to address submission requirements of Contractor's record models.

Add new Part 1 Article "Record Models" to address specific requirements for updates to models.

Section 051200 – Structural Steel Framing (06/21)

Article 1.4 – Preinstallation Meetings
- Paragraph A – Preinstallation Conference: If including a meeting agenda or list of topics to discuss, include construction use on the Project site of the Fabrication Model and Erection Model, bearing the approval comments and final submittal review action.
- Add new paragraph "Predetailing Meeting" to address requirements for structural steel models and their submission. Include such topics as connection design, fabrication model coordinates and general setup, fabrication model metadata, and fabrication model submittal, review, and return procedures, if not fully covered in Division 01 specification sections.

Article 1.5 – Action Submittals
- Add new paragraph "Fabrication Models" before existing paragraph "Shop Drawings" addressing all aspects of fabrication model submittals requirements such as:
  - Allowable software platforms and versions.
  - Hosting platform, licensing, and training if not fully covered in Division 01 specification sections.
  - Model configuration and contents (e.g. single versus federated, structural steel framing only or additional elements such as miscellaneous metals of steel stairs)
  - Model origin point and coordinate system, if not fully covered in Division 01 specification sections.
  - If submitting model files in lieu of cloud-hosted system, types of files to be submitted (e.g. native detail software, IFC).
  - How 2D images (i.e. traditional shop drawings) that are necessary to augment the model will be generated, attached to the model, referenced, and accessed.
  - How submittal review review action will be set.
  - How project team members will attach, reference, and access 2D images that are necessary to augment submittal review comments.
  - Required model and modeled element and assembly metadata parameters.
  - Required LOD by model element and other information necessary to comply with detailing requirements (i.e. AISC 326).
  - How others involved with the project's construction process, such as the Owner's Testing and Inspecting Agency, will have access to the approved fabrication model, if not fully covered in Division 01 specification sections.
- Paragraph C – Shop Drawings
  - Delete paragraph or revise to address primacy of Fabrication Models and the submittal review action indicated in the Fabrication Models.

Add new Article "Closeout Submittals" after **Article 1.6** – Informational Submittals
- Add new article to address closeout model requirements.

Article 1.7 – Quality Assurance
- Add new paragraph "Detailer Qualifications" describing detailer qualifications such as previous experience with importing and exporting models for model review and approval.
- Paragraph A – Fabricator Qualifications, if not fully covered in Division 01 specification sections.
  - Add new subparagraph to require fabricator to employ qualified detailers.

Section 051213 – Architecturally Exposed Structural Steel Framing (06/21)

Follow the same recommendations as for Section 051200 Structural Steel Framing.

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