User Manual for CET.SteelConnDesign V1.10

By CivilEngrTools.com

2025.1

1 Introduction

1.1 General

CET.SteelConnDesign is a **FREE**, cutting-edge steel connection design software that is built on the AISC 13th/14th/15th standards and powered by modern mathematical theories, offering users a powerful design solution. The software can run in 3 modes: **standalone**, integration with **FreeCAD** or integration with **Tekla**. **CET.SteelConnDesign** will also support **Revit** and **Blender** later.

The current version of **CET.SteelConnDesign** is designed exclusively for Windows OS and supports only Imperial units. While the program is not open-source, we are happy to share the source code with our partners upon request.

Additionally, **CET.SteelConnDesign** supports **plugins**, providing users with powerful design tools and a platform to share ideas. As a step toward **Open-Source** development, we are starting with **Open-Source** plugins to foster collaboration and innovation within the community.

The goal of **CET.SteelConnDesign** is not to generate profit but to empower designers by leveraging modern software and saving them time. While it is available for free, we encourage users to explore the enhanced features of our **Premium** service. For more information on accessing Premium benefits, please contact **civilengrtools@gmail.com**. Premium users can enjoy the following advantages:

- Efficiently process thousands of members with just one click. Our software can automatically identify Connection Setup types and design them with minimal user input (under development).
- Utilize **APIs** to customize connection checks or design all connections using specific bolt diameters or plate thickness (under development).
- Open and save project files in plain JSON format.
- Receive hot patches within 5 business days.
- Access feature requests and enhancements.
- Benefit from 24x7 email/video support.
- Attend in-person training sessions.
- Receive 10 developer hours for each Premium user, which can be used for custom connection development.

1.2 Why Choose CET.SteelConnDesign

Followings make **CET.SteelConnDesign** different from others:

1 **Free to use**: The standard version of **CET.SteelConnDesign** lets you explore unlimited connection types, loads, and materials for education, research, or commercial use.

2 **Expertly designed**: Our members, equipped with advanced degrees such as Masters and PhDs, possess profound expertise in Civil Engineering, Mathematics, and Computer programming. Led by a visionary with over two decades of industry experience, our team's strength extends to robust quality assurance and sales support.

3 **User-friendly efficiency**: Unlike competitors, **CET.SteelConnDesign** minimizes user inputs, automatically designing the most efficient connections.

4 **Enhanced inspection**: Enjoy a 3D interactive model created with **FreeCAD** and **Tekla**, allowing you to inspect connections more effectively.

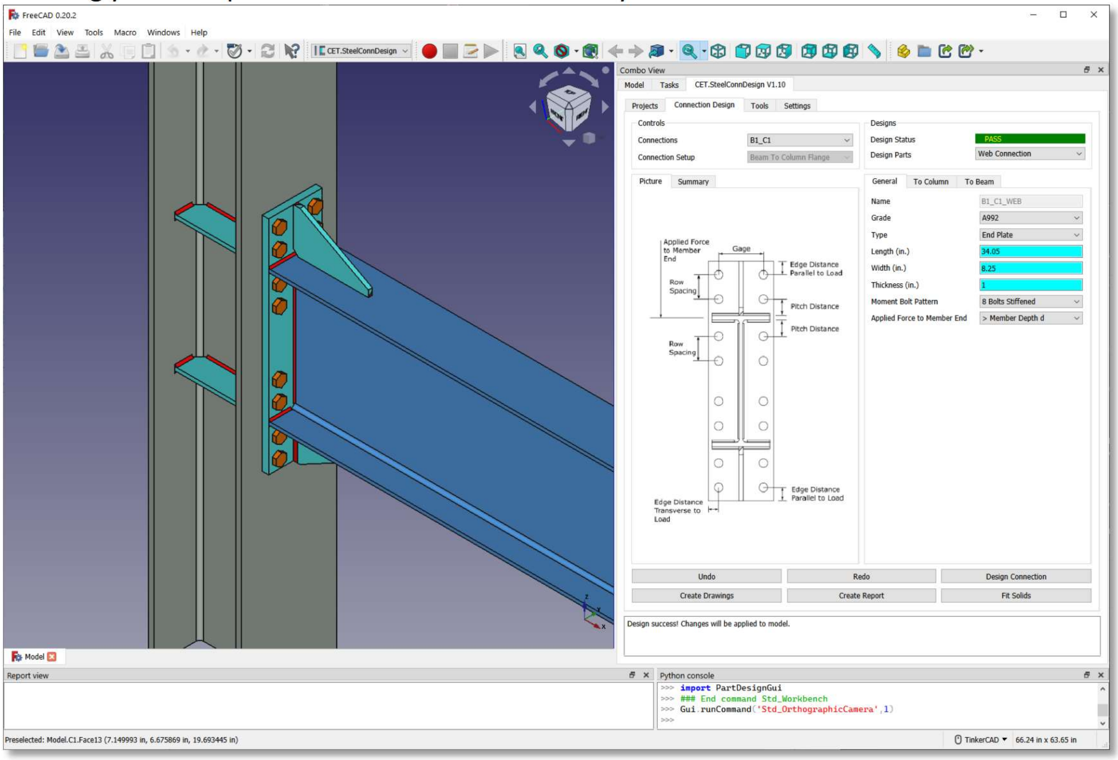

Figure 1.1 Inspection 3D Model in CET.SteelConnDesign with FreeCAD

5 **Simple and powerful**: The software's **Connection-Oriented** and efficient UI system lets you concentrate on specifying connection designs. Unique input fields accurately display user input and design results.

6 **Detailed reports**: Receive comprehensive connection design reports with user-friendly Latex equations, unit calculations, and detailed information.

Check column web compression bucking

$$h = d - 2k = 14.3\text{ in.} - 2(1.46\text{ in.}) = 11.38\text{ in.}$$

$$\phi R_n = \frac{\phi 24 t_{wc}^3 \sqrt{E F_{yc}}}{h} = \frac{0.9(24)(0.525\text{ in.})^3 \sqrt{(29000\text{ ksi})(50\text{ kips})}}{11.38\text{ in.}} = 330.7\text{ kips} \quad \text{(AISC design guide 4 Equ 3.26)}$$

Check column web local yielding

$$N = t_f + 0.707(\text{weld size}) = 0.522\text{ in.} + (0.707)(0.25\text{ in.}) = 0.6987\text{ in.}$$

$$\phi R_n = \phi[C_t(6k_c + 2t_p) + N]F_{yc}t_{wc} = 1[1(6(1.46\text{ in.}) + 2(1\text{ in.})) + 0.69875\text{ in.}](50\text{ ksi})(0.525\text{ in.}) = 300.8\text{ kips} \quad \text{(AISC design guide 4 Equ 3.24)}$$

Check column web crippling

$$\phi R_n = \phi 0.8 t_w^2 \left[1 + 3\left(\frac{N}{d}\right)\left(\frac{t_w}{t_f}\right)^{1.5}\right]\sqrt{\frac{E F_{yw} t_f}{t_w}} = 0.75(0.8)(0.525\text{ in.})^2\left[1 + 3\left(\frac{0.69875\text{ in.}}{14.3\text{ in.}}\right)\left(\frac{0.525\text{ in.}}{0.86\text{ in.}}\right)^{1.5}\right]\sqrt{\frac{(29000\text{ ksi})(50\text{ ksi})(0.86\text{ in.})}{0.525\text{ in.}}} = 272.7\text{ kips} \quad \text{(AISC Equ. J10-4)}$$

Figure 1.2 Detailed Connection Design Report Example

7 **Automated 2D drawing generation**: Our software now automatically generates connection drawings for users, complete with dimensions and annotations (with **FreeCAD** only).

8 **Open-Source Plugins**: Numerous tools, such as steel member properties, operate as plugins within our system. These plugins are open-sourced, and we actively encourage users to develop and integrate their own plugins into the platform.

1.3 Support

If you have any questions, feel free to reach out to us at **civilengrtools@gmail.com**. Premium users have the option to connect with our support team through Skype or Microsoft Teams.

1.4 Social Media

Youtube:
https://www.youtube.com/@civilengrtools6051

Facebook
https://www.facebook.com/people/CivilStructural-Engineering-Tools/100083589511709/

Linkedin
https://www.linkedin.com/company/civilengrtools (need login)

Twitter
https://twitter.com/CivilEngrTools (need login)

Reddit
https://www.reddit.com/r/SteelConnDesign/

Website
https://civilengrtools.com/

1.5 Join Us

We are a team of skilled engineers located in multiple places around the world. However, we need your help to promote our sales. As a sales representative, you can earn a percentage of premium subscriptions for each sale. Please reach out to us at **civilengrtools@gmail.com** if you have any questions or requests. Additionally, you can showcase your skills by contributing to our open-sourced plugin system. We welcome your expertise and collaboration!

1.6 Investment Opportunities

We are an emerging startup with a promising future and are actively seeking investment opportunities. If you are interested in partnering with us, please do not hesitate to contact us.

1.7 Version History

Table 1.1 CET.SteelConnDesign Version History

Version Number	Notes
V 1.10	1 Support **moment beam splice** connections 2 Added bolt solids in FreeCAD for 3D models and 2D drawings. 3 Introduced color settings for members and connections in FreeCAD.
V 1.9	Support beam web **angle** connections and **tension**/**compression** axial forces
V 1.8	Support beam flange blocks (FreeCAD Only), extended single plate and stabilizer plate connection
V1.7	1 Support **beam splice** connections (non-moment connection) 2 Fix UI bugs like not being able to change design codes
V1.6	Support **beam to beam web** connections
V1.5	Support automated **2d drawing** generation (FreeCAD only)
V1.4	Support **beam to column, moment end plate** connection
V1.3	Support beam to column, **end plate** connection
V1.2	Support **column transverse stiffener** in beam to column flange, moment connection
V1.1	Support beam to column flange, **moment flange plate** connection
V1.0	First Release: Beam to column **single plate** connection

1.8 Road Map

CET.SteelConnDesign is evolving gradually. In upcoming releases, we plan to introduce support for column splice connections, brace connections and others. **Eurocode** will be implemented soon (around 2026). We also will support CET.SteelConnDesign in Linux platform for FreeCAD**.** In the long term, our goals include:

- Expanded design codes support
- Integration of seismic design

- Implementation of **AI** for connection design
- Import IFC models

1.9 Legal Disclaimer:

When installing and using our software, users are assumed to agree with the terms outlined in the **License Agreement**.

2 Using Software

2.1 Download CET.SteelConnDsign

Please check github link for current version:
https://github.com/CivilEngrTools/SteelConnDesign/releases

Note: Source code is not provided. For collaboration opportunities, please reach out to civilengrtools@gmail.com.

2.2 Install CET.SteelConnDsign

Please check following video tutorial:
https://www.youtube.com/watch?v=AF5v379huTA

Note: CET.SteelConnDesign does not require administrator privileges to install.

2.3 Using CET.SteelConnDesign with FreeCAD

2.3.1 Download FreeCAD

Please use **FreeCAD 0.20.2** (https://github.com/FreeCAD/FreeCAD/releases/tag/0.20.2). We are currently working on **FreeCAD 1.0** and future versions. However, FreeCAD 1.0 introduces significant API changes, and we are still in the testing phase.

2.3.2 Setup FreeCAD for CET.SteelConnDesign

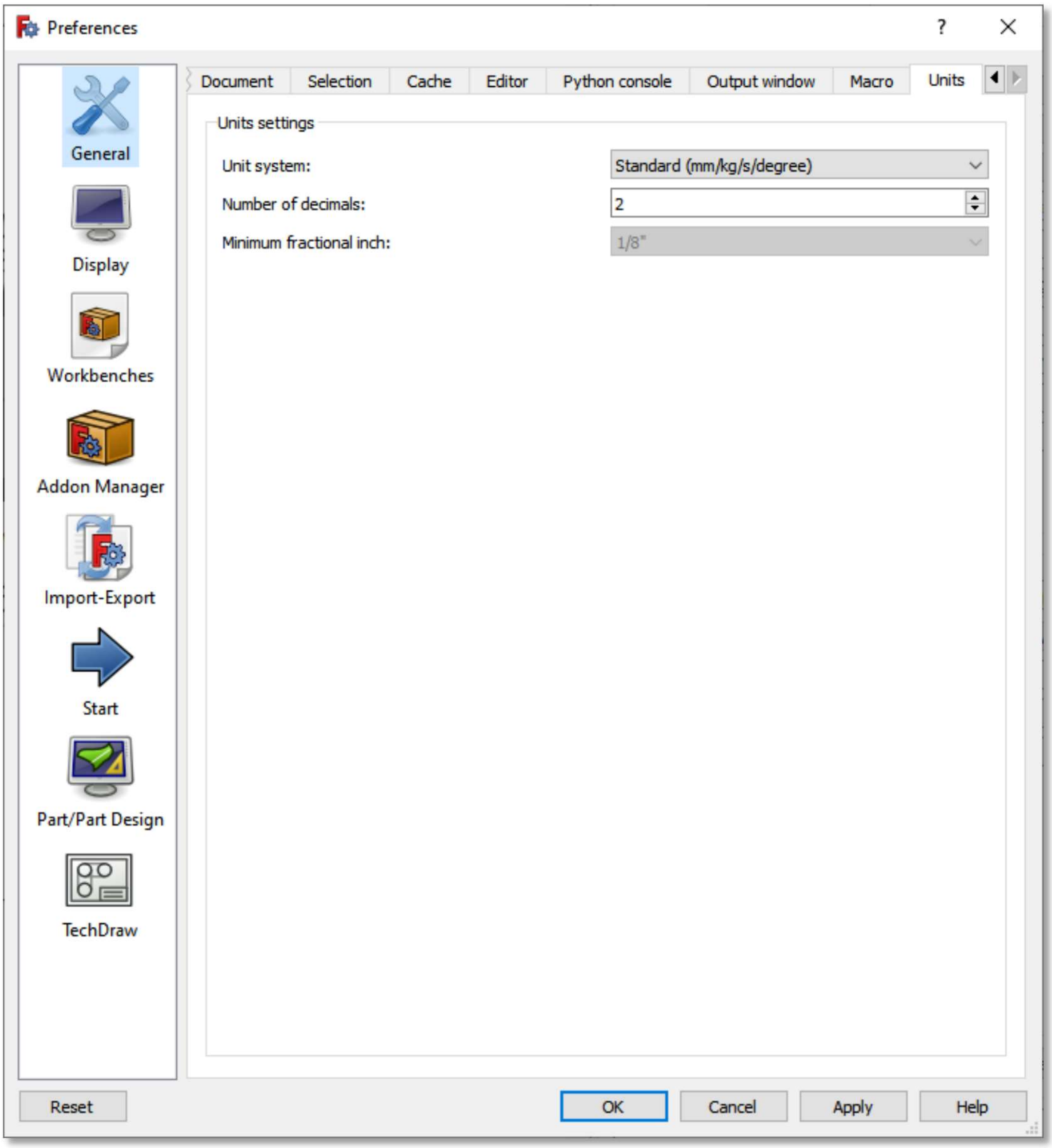

Figure 2.1 FreeCAD Setup, Units

1 Change “Unit system” to “US customary (in/lb)”
2 Change “Number of decimals” to 4

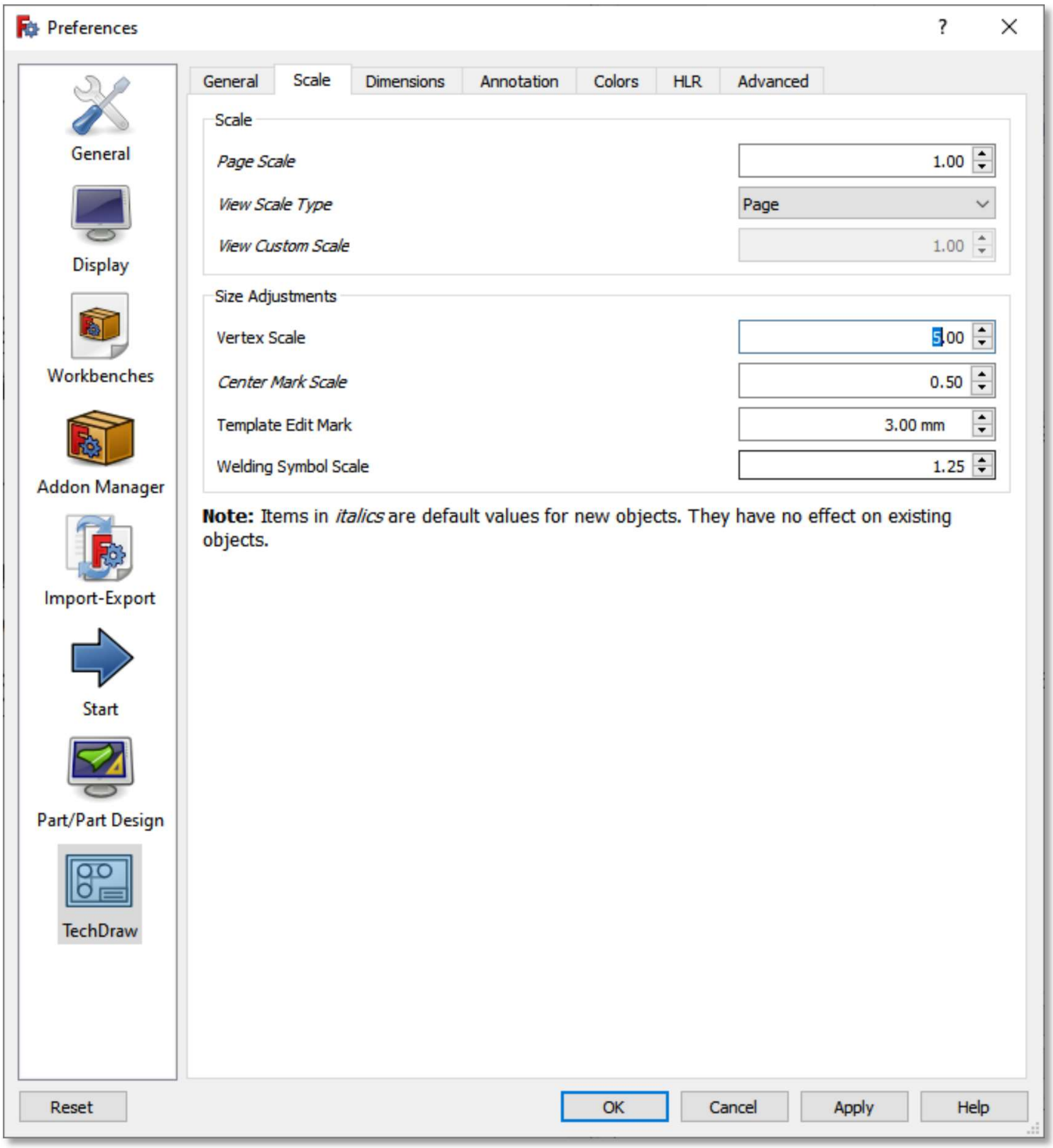

Figure 2.2 FreeCAD Setup, Scale

1 Change "Vertex Scale" to 3.0
2 change "Welding Symbol Scale" to 1.0

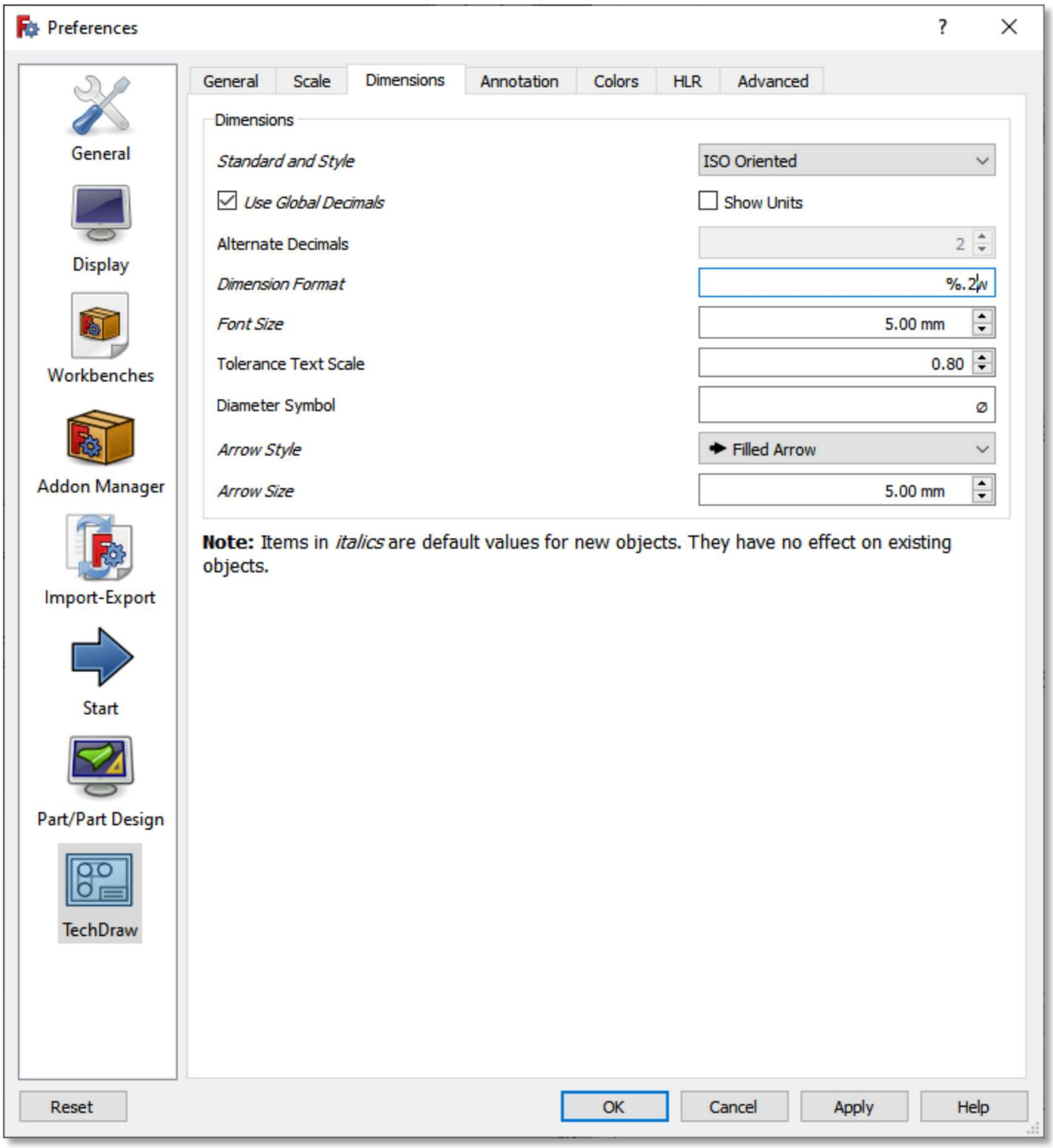

Figure 2.3 FreeCAD Setup, Dimension

1 Change "Dimension Format" to "%.4w"
2 Change "Arrow Size" to "2.5 mm"

2.4 Using CET.SteelConnDesign with Tekla

Starting with CET.SteelConnDesign V1.9, we now support Tekla versions **2021** through **2024**. However, we strongly recommend using the latest Tekla version, as most of our testing efforts are focused on it. Please check our Youtube channel (https://www.youtube.com/@civilengrtools6051/videos) for details. Here are two important instructions:

1. Open Tekla before CET.SteelConnDesign.
2. Give each Tekla member a unique name like "B1" for beams or "C1" for columns. This helps CET.SteelConnDesign distinguish members and create connections.

2.5 User Interface

2.5.1 Shared UI for Integration With FreeCAD and Tekla

CET.SteelConnDesign features a unified UI system that operates consistently across both FreeCAD and Tekla. This means that most UI operations are the same whether you're using FreeCAD or Tekla. However, some functionalities are exclusive to FreeCAD and are not available in Tekla, such as the beam flange block operations.

2.5.2 Main User Interface

CET.SteelConnDesign features two primary tabs: the "Projects" tab, dedicated to projects, and the "Connection Design" tab, focused on managing connections. Refer to our YouTube channel, [https://www.youtube.com/@civilengrtools6051/videos,](https://www.youtube.com/@civilengrtools6051/videos) for tutorial videos.

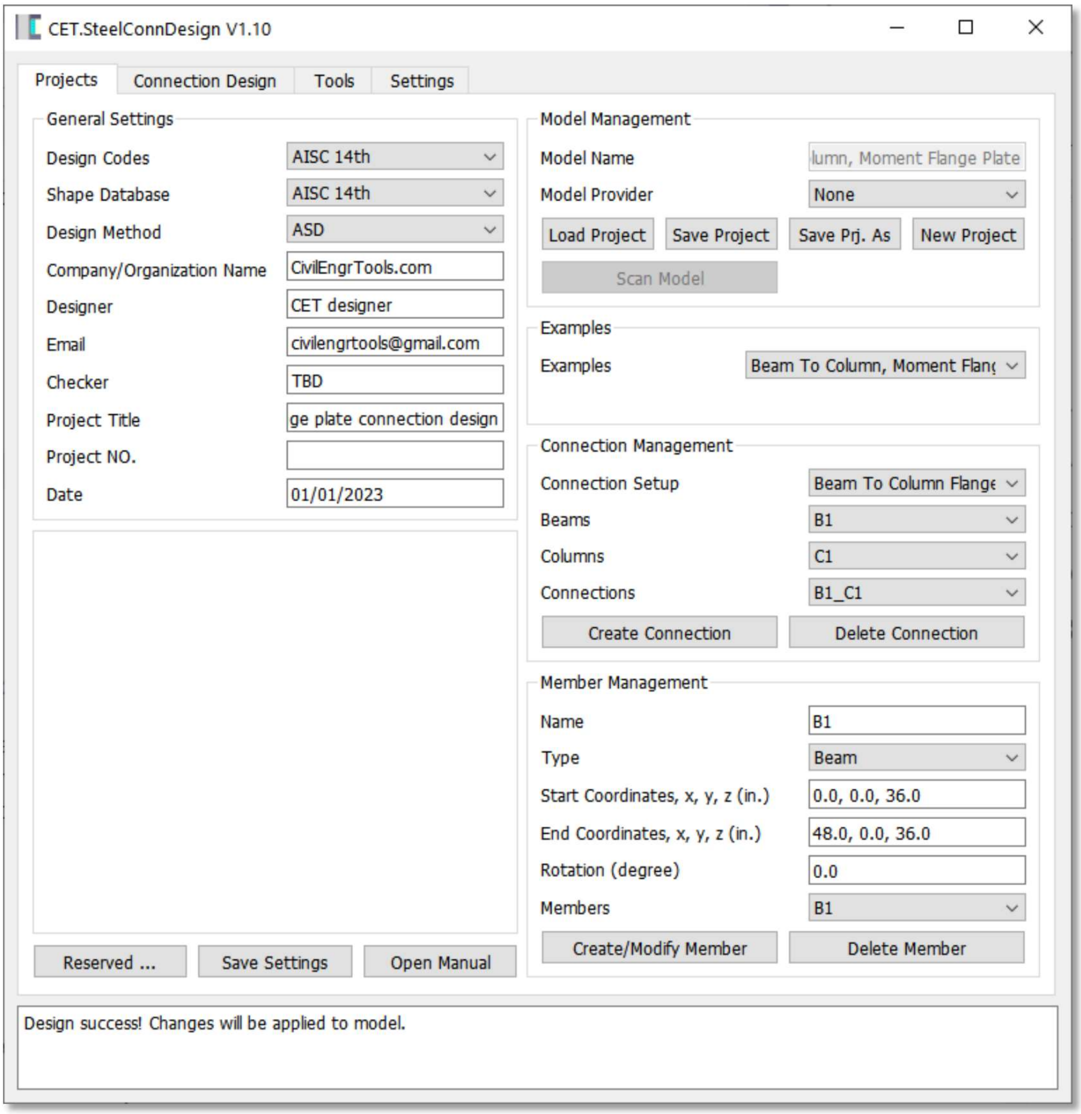

Figure 2.4 UI, Project Tab

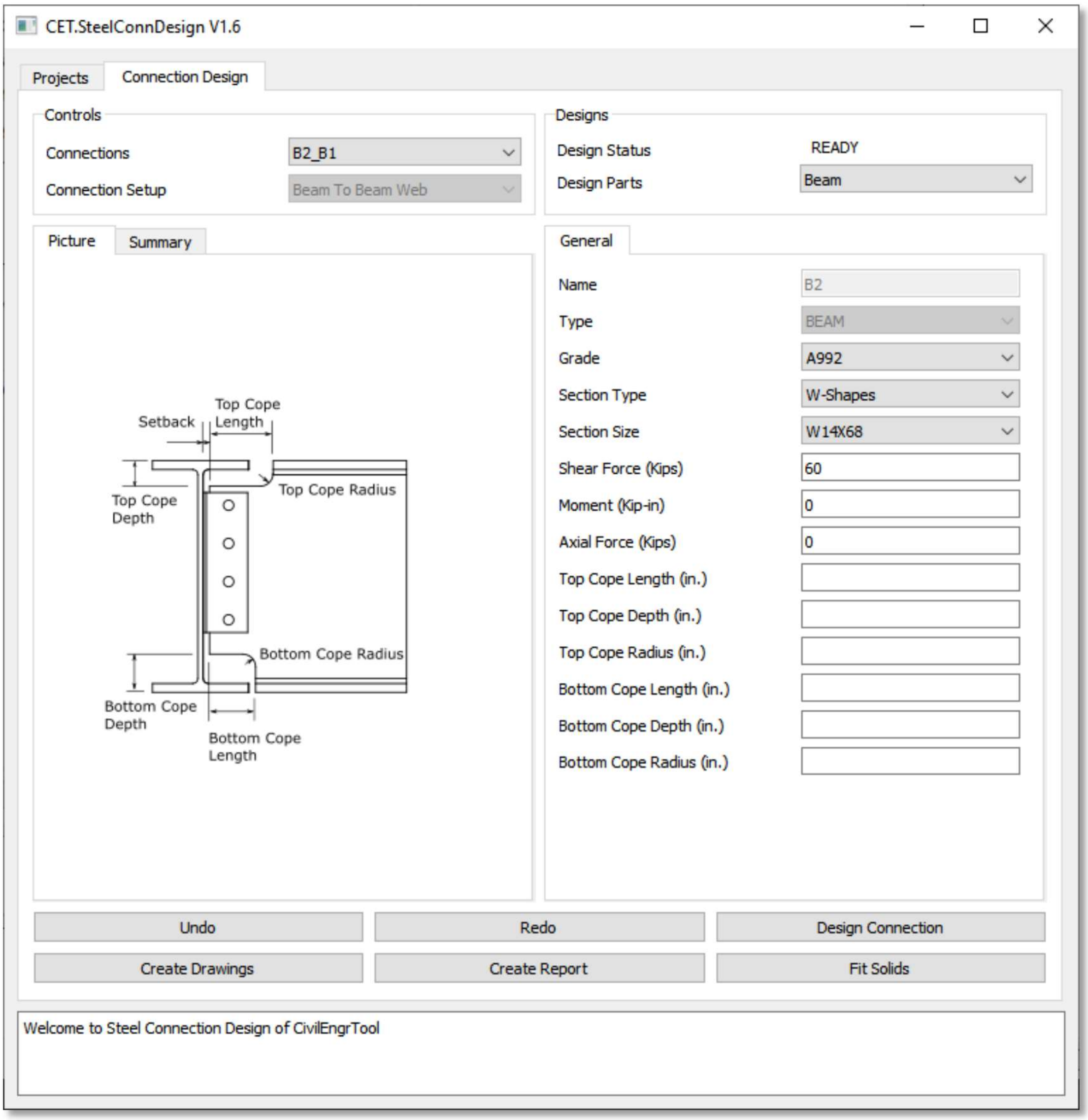

Figure 2.5 UI, Connection Design Tab

2.5.3 Undo and Redo

In CET.SteelConnDesign, **Undo** and **Redo** functionalities are available exclusively within the "Connection Design" tab. It's important to note that Undo and Redo operations do not initiate any changes in the connection design itself.

2.5.4 Input Fields

The input fields in CET.SteelConnDesign exhibit three distinct statuses: user inputs, system-designed values, and fields with no inputs.

User Inputs

This is similar to other software. Our software will use the inputs for the connection design. Note that some fields have default values such as plate grades.

System-designed Values

In the case where a user does not input values, our software takes charge of designing the connection. The design results are then displayed in the input field, **highlighted** in a distinctive cyan color by intelligent algorithm. This unique feature not only allows users to easily review and verify the design outcomes but also provides the most efficient connection design. For example, under different shear forces, our software designs a beam to column flange, single plate connection as:

Table 2.1 Single Plate Design Results under Different Shear Forces

Shear Force (Kips)	Length (in)	Width (in)	Thickness (in)	Bolt Row	Bolt Dia. (in)	Ratio
10	5	3.5	0.25	2	0.75	0.71
20	5	4	0.375	2	0.875	0.88
30	8	3.5	0.375	3	0.75	0.86
40	11	3.5	0.3125	4	0.75	0.98
50	11.5	4	0.4375	4	0.875	0.88
60	11.5	4	0.5	4	0.875	0.92

Where ratio = shear force / min capacity

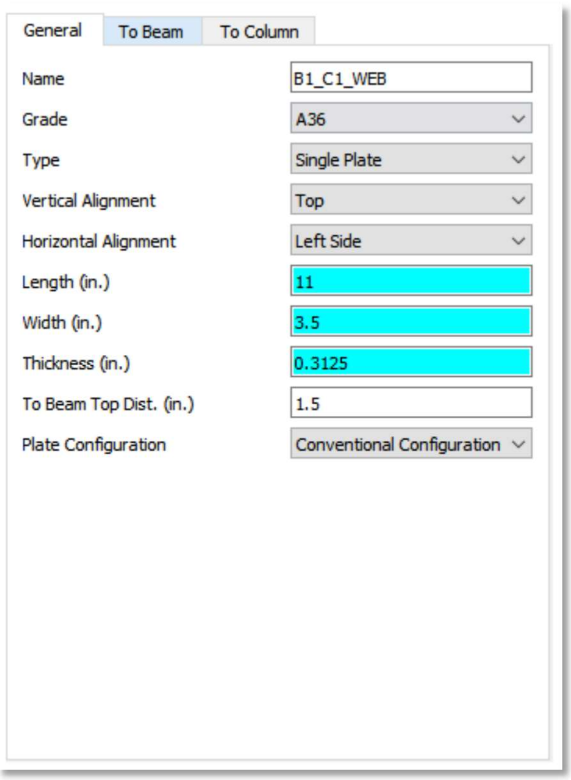

Figure 2.6 System-designed Values Highlighted in a Cyan Color

Fields with no inputs

Certain fields, like the column transverse stiffener, may not necessitate user inputs and won't display results in specific situations. However, even if our system doesn't typically design a column transverse stiffener, providing input for parameters like stiffener thickness or clip length will prompt our system to generate the stiffener design for you.

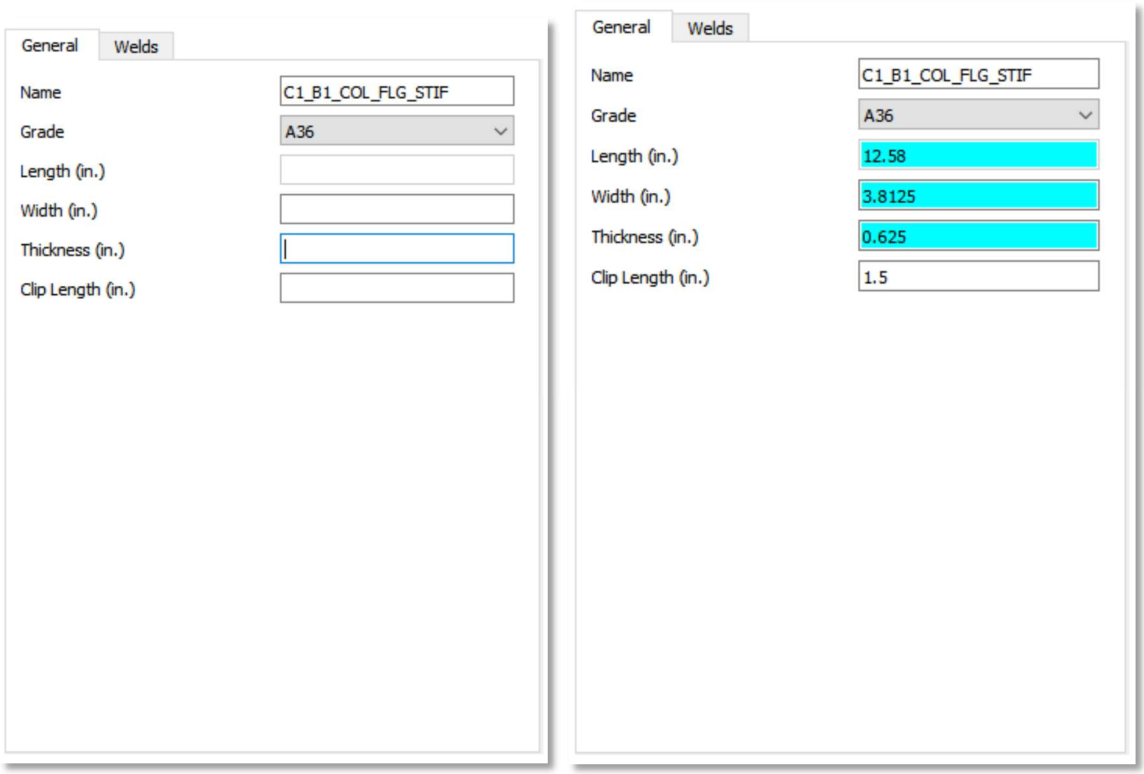

Figure 2.7 User Input Clip Length Will Trigger the Column Transverse Stiffener Design

2.5.5 Switch Between Design Parts

CET.SteelConnDesign operates as a **Connection-Oriented** design software with a user interface focused on connections. The "Design Parts" dropdown facilitates efficient navigation between various members, connections or parts for the user. Additionally, selecting a different design part triggers the Picture panel to display the corresponding image with annotations, enhancing the user's understanding of the input fields.

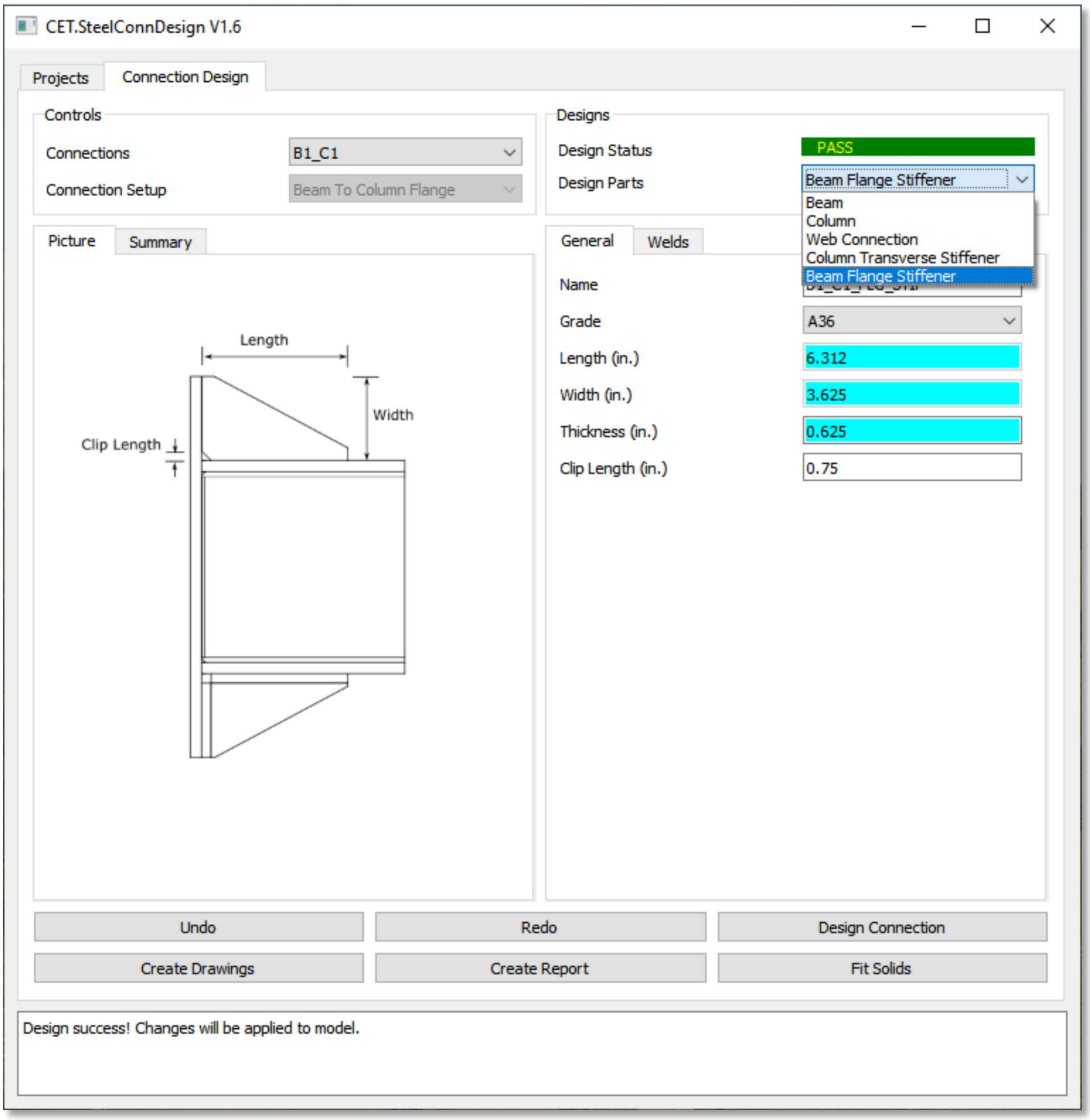

Figure 2.8 Switch Between Design Parts

3 Connection Design

3.1 Connection Setup

In the current version, our software offers support for four connection setups (in “Projects” tab): **Beam to Column Flange**, **Beam to Column Web**, **Beam to Beam Web** *and* **Beam Splice**. It's important to note that both beams and columns must be W Shapes. All three setups are designed to accommodate shear forces. However, not all setups are equipped to handle axial forces (tension and compression) and moments. Refer to the table below for a detailed overview:

Table 3.1 Forces, Moment and Connection Setup

Connection Setup	Shear Load	Axial Load	Moment
Beam to Column Flange	Yes	Yes	Yes
Beam to Column Web	Yes	Yes	No
Beam to Beam Web	Yes	No	No
Beam Splice	Yes	Yes	Yes

3.1.1 Beam To Column Flange/Web

At the beam web, three connection types are available: Angle, Single Plate, End Plate.

3.1.2 Beam To Beam Web

Important points to consider:

1. Ensure that the main beam shares the same top elevation as the girder (other beam).
2. The main beam should not have a greater depth than the girder (other beam).
3. Do not support axial load or moment.
4. Three connection types are available: Angle, Single Plate, End Plate.

3.1.3 Beam Splice

Important points to consider:

1. Ensure that the both beams shares the same top elevation.
2. Only support Single Plate connection at beam web.
3. Even if our system supports flange filler plates, it is highly recommended to apply a beam splice connection to two beams of the same size. If designing with different beam sizes, it is advisable to limit size variations to a single category. For example, connecting a W**18**X60 beam to a W**16**X89 beam is acceptable, but connecting it to a W**14**X99 beam is not, as this would require a thicker flange filler plate. For Tekla-specific guidelines, please refer to section 3.5.2.
4. For both standalone use and integration with FreeCAD, users are allowed to input different shear forces, moments, bolt rows, or diameters for the two beams. However, from a structural engineering perspective, using different inputs is not appropriate for beam splice connections. We strongly recommend avoiding this practice.

3.2 General Connection Design

3.2.1 Input Forces and Moments

Our software supports the design of connections with Shear force, Moment, Tension axial force, and Compression axial force. For beam web connections, Shear force is required, and Moment, Tension, and Compression forces can also be applied if necessary.

For non-moment connections, if Tension or Compression forces are provided, the software will evaluate the interaction between Shear, Tension, and Compression forces. However, certain checks, such as block shear check, are not applicable when Compression force is present.

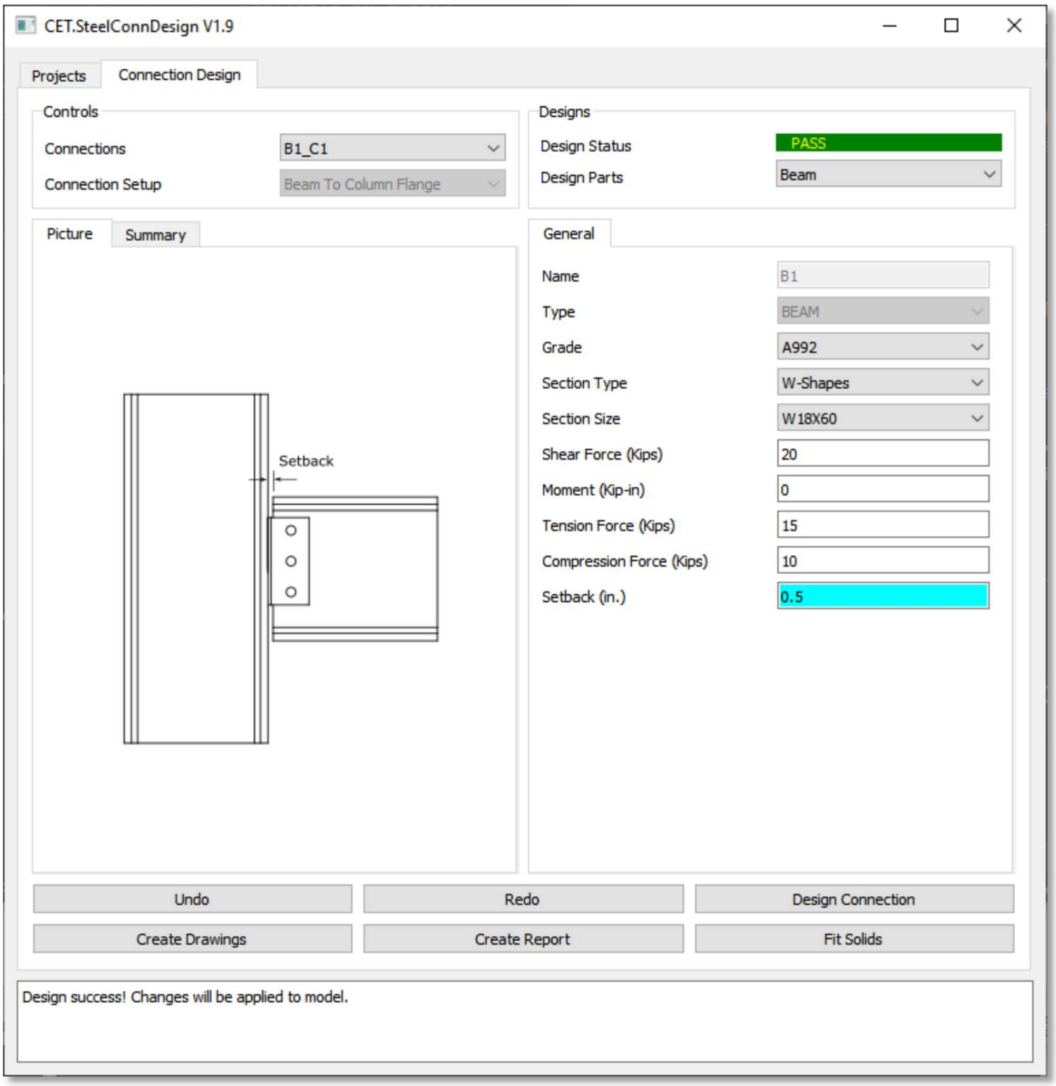

Figure 3.1 Input Forces and Moments

3.2.2 Bolt Design

Please see AISC Specification J3.

3.2.3 Weld Design

Please see AISC Specification J2.

3.2.4 Bolt Spacing and Edge Distance

Please see AISC Specification J3.

3.2.5 Connection Subject to Shear Force Only

For beam web connections like the single plate and end plate, they're designed to handle shear loads only. We'll check their capacities specifically for shear strength, ensuring they can withstand the applied shear forces.

- Bolt (AISC Specification J3)
- Bearing (AISC Specification J3.10)
- Shear Yielding (AISC Specification J4.2)
- Shear Rupture (AISC Specification J4.2)
- Block Shear (AISC Specification J4.3)
- Weld (AISC Specification J2)

3.2.6 Connection Subject to Shear Force and Axial Force

For beam web connections like the single plate and end plate, we're not only checking their capacity for shear loads but also considering the interaction with axial loads. This means making sure they can handle both shear and axial forces together. In addition to 3.2.4, followings will be checked:

- Tensile Yielding (for the axial load, AISC Specification J4.1)
- Tensile Rupture (for the axial load, AISC Specification J4.1)
- Block Shear (for the axial load, AISC Specification J4.3)
- Interaction of axial, flexural and shear yielding (AISC Specification H1)
- Interaction of axial, flexural and shear rupture (AISC Specification H1)
- Interaction of axial, flexural and block shear (AISC Specification H1)

Please note that bolts, bearing and welds will be check against the combined shear force and axial force.

3.2.7 Connection Subject to Shear Force, Axial Force and Moment

For the Beam to Column Flange setup, the resistance against moments is primarily handled by the connection to the beam flange, such as the beam flange plate connection. In the presence of axial load, the force on the beam flange (f) due to the axial force (P) and moment (M) is calculated using the formula:

$$f = \frac{M}{d} + \frac{P}{2}$$

Where d is the moment arm length.

Besides, he eccentricity of beam web bolt group will be ignored.

3.2.8 Connection Subject to Axial Force Only

For the beam-to-column flange connection with a moment, we'll check if the beam flange plate can handle axial force and the combined effect of axial force and moment.

- Bolt (AISC Specification J3)
- Bearing (AISC Specification J3.10)
- Tensile Yielding (for the axial load, AISC Specification J4.1)
- Tensile Rupture (for the axial load, AISC Specification J4.1)
- Block Shear (AISC Specification J4.3)
- Weld (AISC Specification J2)

3.3 Typical Connections

3.3.1 Beam Web

For beam web subject to the shear force, we will check

- Bearing (AISC Specification J3.10)
- Shear Yielding (AISC Specification G2)

Please be aware that the examination for shear yielding is in accordance with AISC Specification G2.

Furthermore, the evaluation of the coped beam web's strength will be conducted according to AISC Part 9. This assessment includes examinations for both flexural strength and flexural local buckling strength. Cope dimensions can be manually adjusted through the UI; however, the top and bottom cope dimensions will be the same in Tekla.

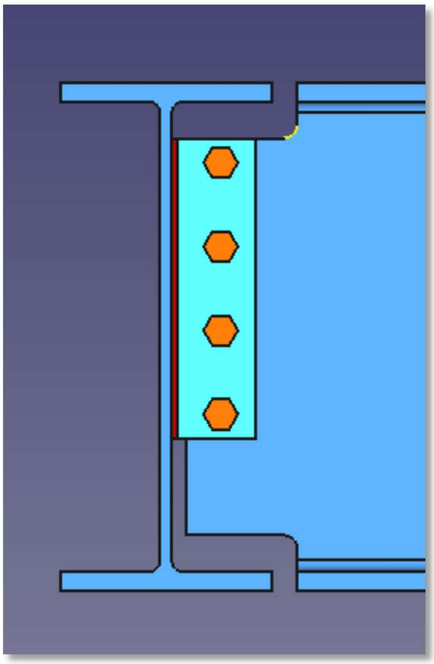

Figure 3.2 Beam Top and Bottom Copes in 3D Model

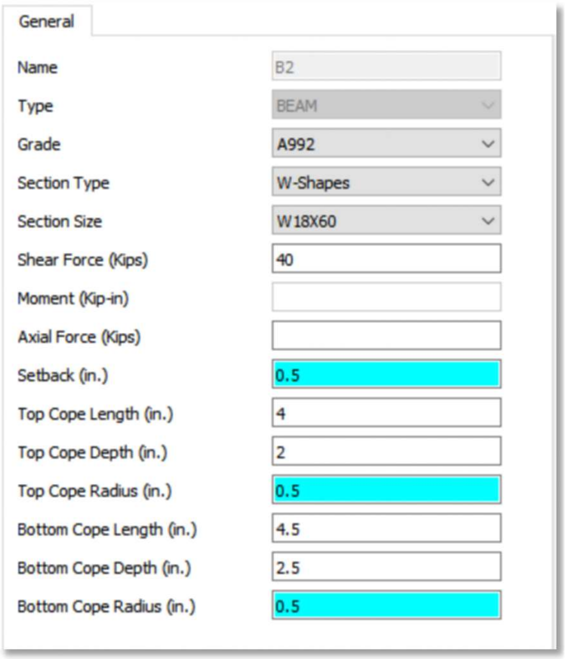

Figure 3.3 Beam Top and Bottom Copes in UI

3.3.2 Beam Flange

For beam-to-column web connections, the beam flange block design is supported in CET.SteelConnDesign standalone version and in integration with FreeCAD. However, 2D detailing for beam flange blocks will be supported in a future version.

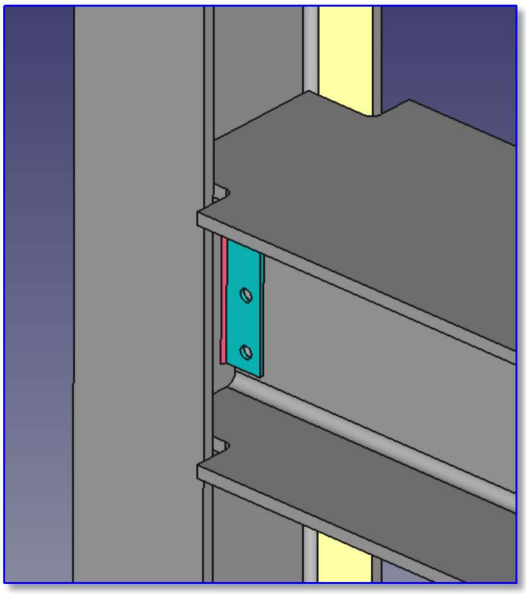

Figure 3.4 Beam Flange Blocks in 3D Model

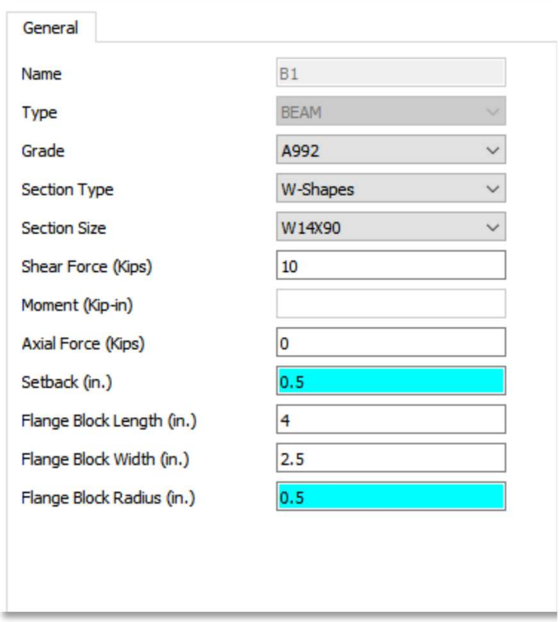

Figure 3.5 Beam Flange Blocks in UI

3.3.3 Angle Connection (Beam Web)

3.3.3.1 General

The **Angle** connection is more *complex* compared to **End Plate** or **Single Plate** connections. Currently, our software supports only **Angle** connections that are bolted to the beam web and bolted to either another beam or a column. Welded **Angle** connections will be available in a future version. Users can design either single-sided or double-sided angle connections, but double-sided connections are strongly recommended unless construction requirements specifically call for a single-sided connection. The UI for the angle connection:

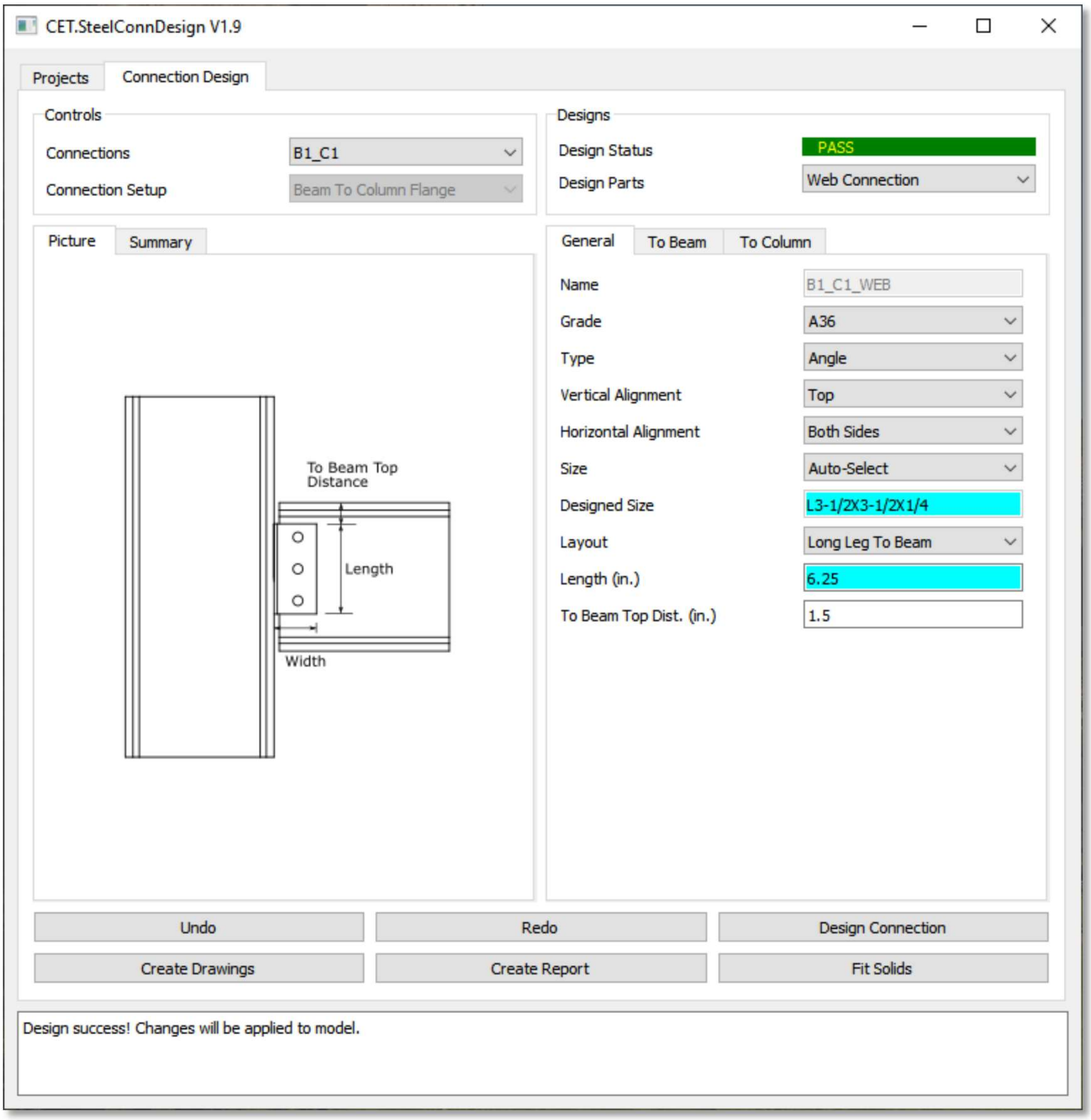

Figure 3.6 Angle Connection at Beam Web

3.3.3.2 Angle Size

CET.SteelConnDesign is one of the few software options that can automatically select an **optimal** angle size, significantly saving the designer's time. We highly recommend choosing 'Auto-select' in the 'Size' dropdown. However, users can still manually select their preferred angle size. When 'Auto-select' is enabled, the designed size will appear in cyan within the 'Designed Size' field. In future updates, the 'Size' and 'Designed Size' UI elements will be further streamlined for ease of use.

3.3.3.3 Bolt Eccentricity

According to AISC Steel Manual Part 10 (15th Edition, Page 10-9), for double-angle connections, eccentricity on the supported side can be ignored if there is only one vertical row of bolts through standard or short-slotted holes and the distance labeled 'a' (distance from angle face to bolt line) is 3 inches or less. In all other cases, eccentricity must be considered.

3.3.3.4 Bolt Location and Angle Gage

In single-sided angles, the term 'gage' refers to the distance from the angle toe to the bolt line, which differs from its meaning in double-sided angles. Please refer to the following figure for clarification.

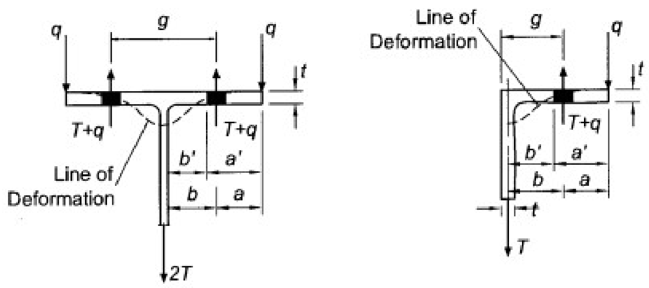

Figure 3.7 Angle Gages

When determining angle locations, our software references the following tables from the AISC Steel Manual:

- Table 1-7A, “Workable Gages in Angle Legs” (15th Edition, Page 1-52)
- Table 1-1, “W-Shapes” for workable gages (15th Edition, Page 1-12)
- Table 7-15, “Entering and Tightening Clearance” (15th Edition, Page 7-80)

If users manually input the gage value, only the workable gages for angles and W-shapes are validated.

It's important to note that larger bolt diameters, as specified in the 'Entering and Tightening Clearance' guidelines, increase the space requirements within angle legs. For angle connections, smaller bolt diameters, such as 5/8” or 3/4”, are generally preferred to optimize fit and clearance.

3.3.4 End Plate Connection

Please check AISC Manual Part 10 for the Shear End-Plate connections.

3.3.5 Single Plate Connection

Please look at AISC Manual Part 10 for the Single-Plate connections. In our software, users can opt for either the "Conventional Configuration" or "Extended Configuration". The "Conventional Configuration" features a smaller bolt group eccentricity and may result in a smaller single plate, but it comes with certain limitations. On the other hand, the "Extended Configuration" is recommended when uncertain. Please check following references:

AISC 13th Page 10-101, AISC 14th Page 10-102 and AISC 15th Page 10-87

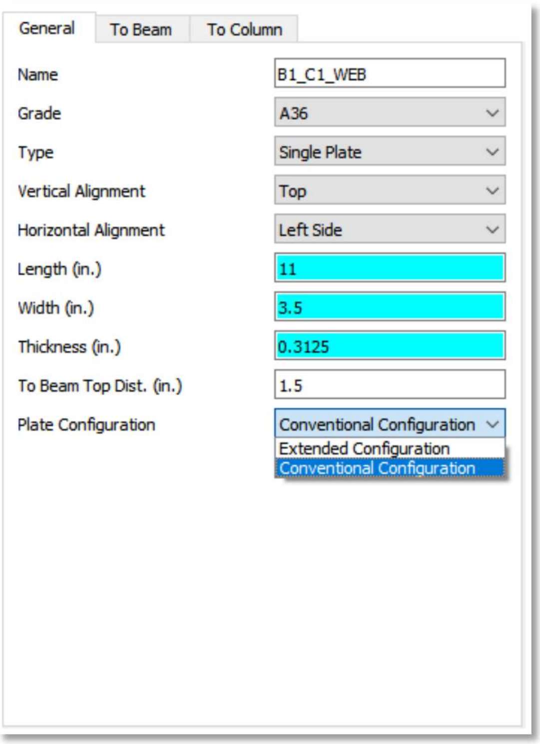

Figure 3.8 "Plate Configuration" Dropdown in Single Plate Connection Design

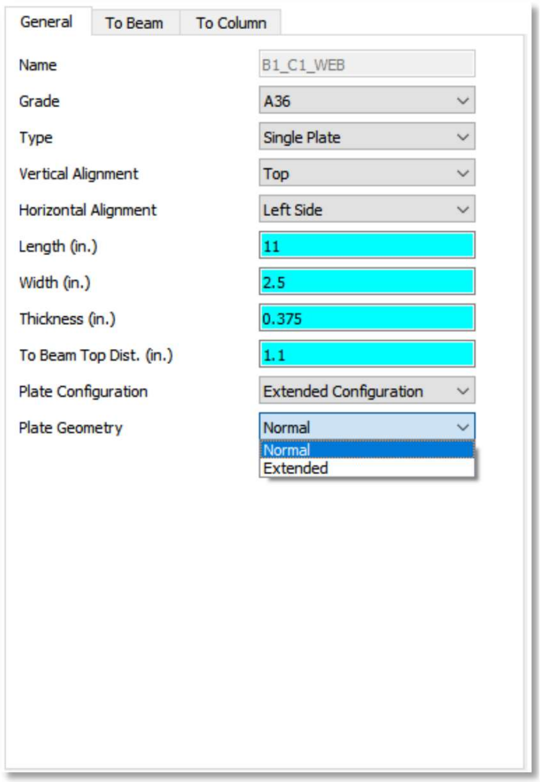

Figure 3.9 "Plate Shape" Dropdown in Single Plate Connection Design

Starting from version 1.8, a new field called "Plate Shape" has been added, with two options: "Normal" and "Extended." This field is only available for beam-to-column web connections. Please note the following:

1) An extended single plate will have a larger bolt group eccentricity and reduced bolt shear capacities. For example, a normal single plate with 5 rows of bolts has a bolt shear capacity of 74 kips, while an extended single plate with the same bolts has a bolt shear capacity of 45 kips, representing approximately a 40% decrease.

2) When "Extended" is selected for "Plate Shape," "Extended Configuration" must also be selected for "Plate Configuration." Otherwise, the connection will fail.

3.3.6 Moment End Plate Connection

Please see Design Guide 4: Extended End-Plate Moment Connections Seismic and Wind Applications.

Notes: User need to input correct moment loads. Axial load is not support for this connection.

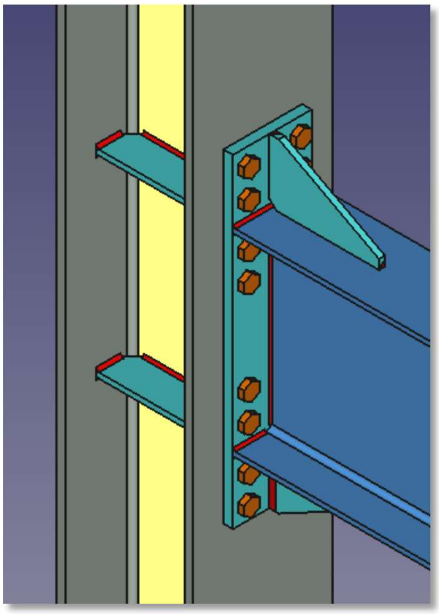

Figure 3.10 Moment End Plate in 3D Model

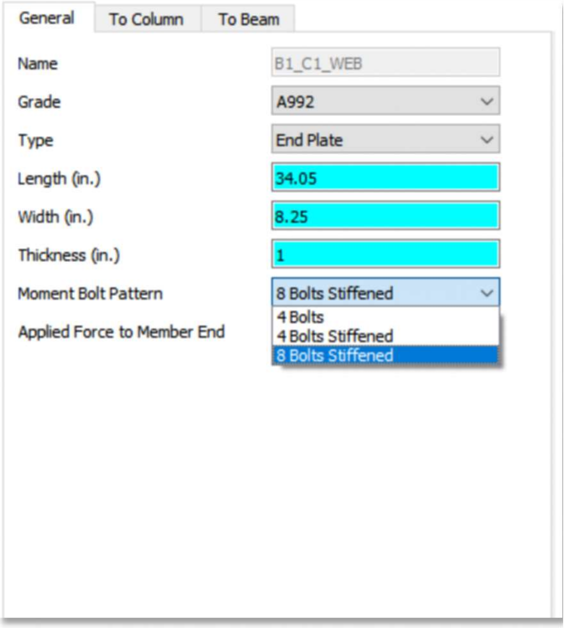

Figure 3.11 Moment End Plate in UI

3.3.7 Column Transverse Stiffener

Please refer to AISC Design Guide 4: Extended End-Plate Moment Connections for Seismic and Wind Applications. It's important to note that our system designs column transverse stiffeners only when necessary, as the cost of these stiffeners is high. In some instances, changing the column size can eliminate the need for stiffeners, which is highly recommended.

Even if our system does not design these stiffeners automatically, users can still input values, such as the clip length. The system will then design the stiffeners and generate the corresponding drawings.

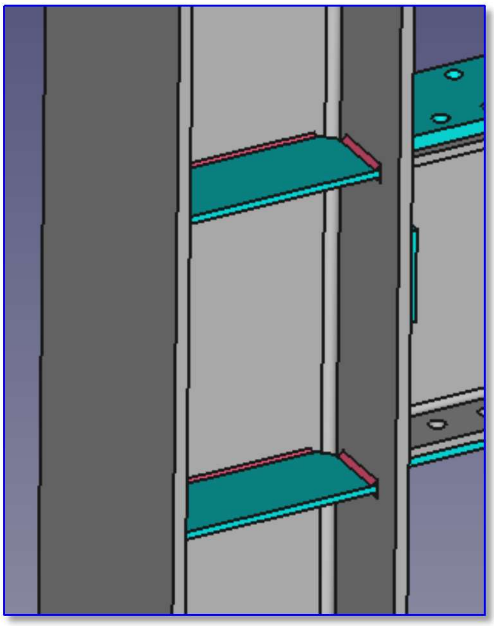

Figure 3.12 Column Transverse Stiffeners in 3D Model

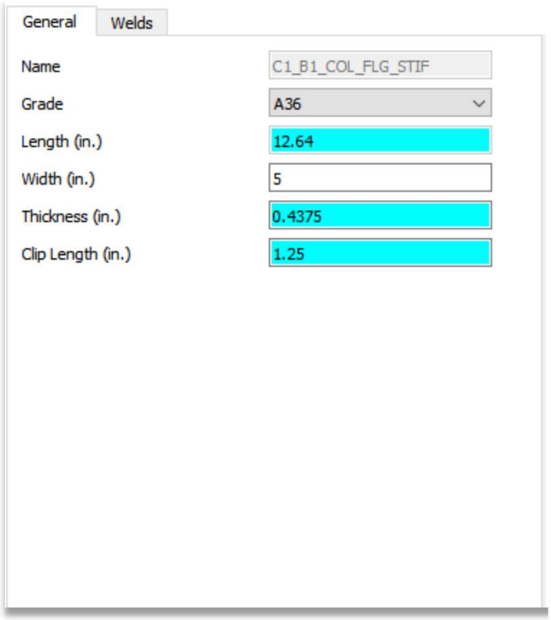

Figure 3.13 Column Transverse Stiffeners in UI

3.3.8 Beam Flange Stiffener

Please check AISC Design Guide 4: Extended End-Plate Moment Connections Seismic and Wind Applications.

3.3.9 Stabilizer Plate

This feature is only available for beam-to-column web extended single plate connections. Currently, the presence of the stabilizer plate does not affect the bolt group eccentricity of the extended single plate. However, we may offer UI settings to allow for such changes in the future.

Similar to the column transverse stiffeners, users can enter values for the plates, and our system will create them even if they are not required.

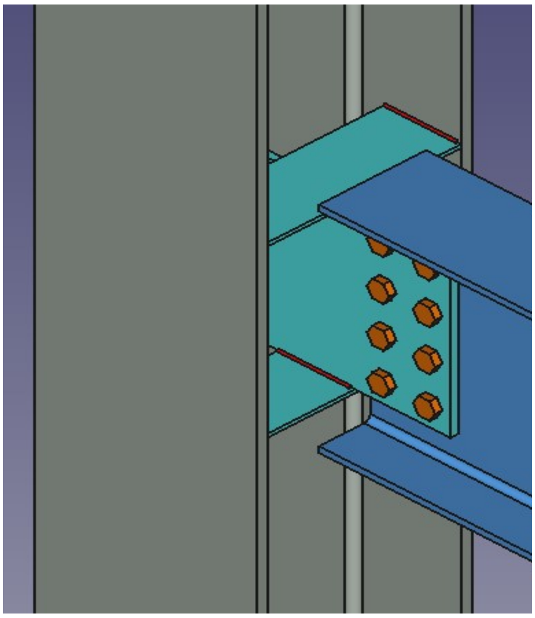

Figure 3.14 Stabilizer Plate in 3D Model

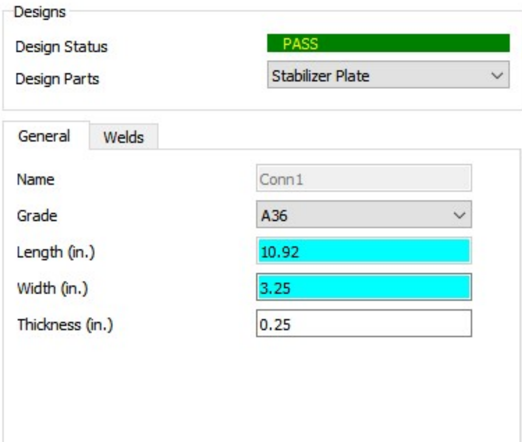

Figure 3.15 Stabilizer Plate in UI

3.4 Notes For Standalone and Integration with FreeCAD

3.4.1 General

In a beam splice, the splice plates for the current beam and the splice plate can be designed separately based on different shear loads. However, both plates will share the same "To Center Line Transverse to Load" and number of bolt groups columns. User can adjust bolt diameter or edge distance for both plates.

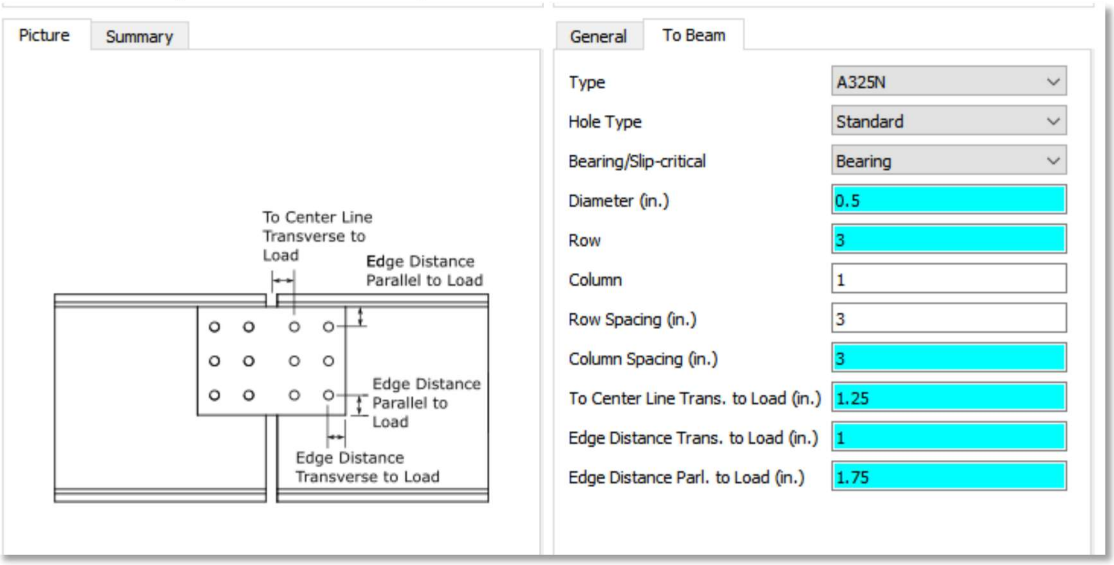

Figure 3.16 Inputs for Beam Splice Connection

3.5 Integration With Tekla and Known Issues

3.5.1 General

For a beam splice, the splice plate in the current beam and the splice plate in the opposite beam are symmetrical.

3.5.2 Known Issues

1 When selecting the "Right Side" plate configuration for a **Beam Splice** connection in Tekla, two plates will be displayed. Despite this, the design and calculations are correct. Therefore, in Tekla connection 77, under the "Parameters" tab, users should adjust the plate side to the right side.

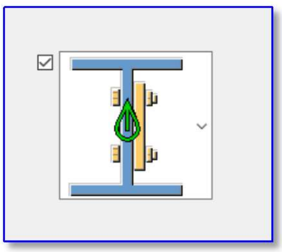

Figure 3.17 Tekla Plate Side for Beam Splice Connection

2 (Fixed in Tekla V2024) For **Beam to Column Web**, extended single plate connections with a stabilizer plate, the welds between the stabilizer plate and the single plate are missing. Users need to manually add these two welds.

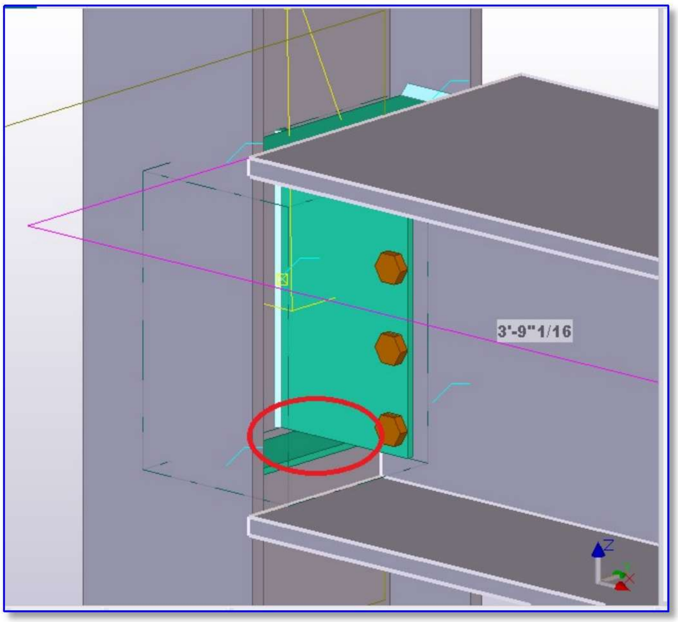

Figure 3.18 Missing Welds between the Stabilizer Plate and the Single Plate

3 It is recommended to use a beam splice connection for joining two beams of the same size. However, Tekla currently does not support flange filler plates in connection 77, so users must manually add the flange plate when connecting beams of different sizes..

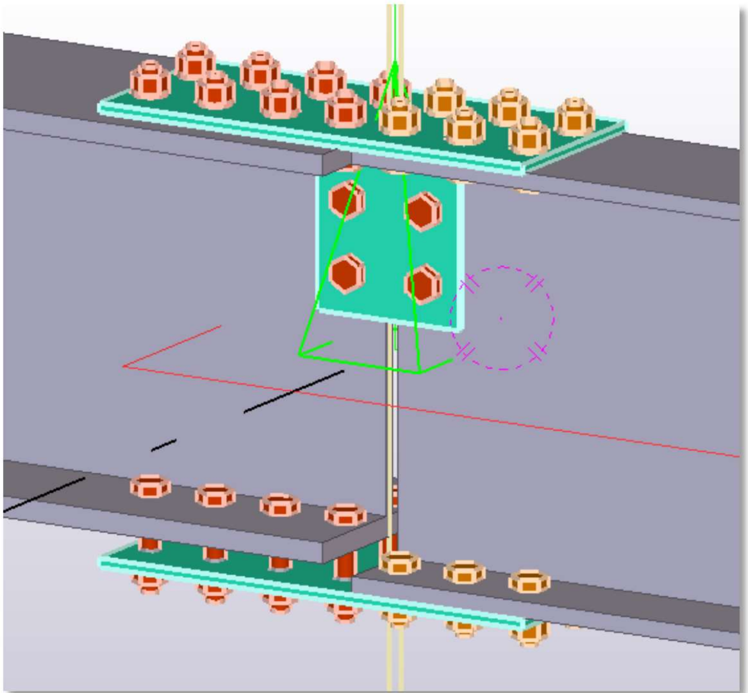

Figure 3.19 The user must manually add a flange filler plate in the beam splice connection.

4 Report and Drawings

4.1 Detailed Connection Design Report

Your design reports in CET.SteelConnDesign have distinct characteristics that set them apart in the market:

1 Connection Geometry and Strength Limitations:
Comprehensive checks on connection geometry limitations and strength constraints ensure a thorough assessment.

2 Real Connection Sketches with Dimensions (Only for FreeCAD):
Integration with FreeCAD allows for the presentation of authentic connection sketches accompanied by precise dimensions, enhancing visual clarity.

3 Step-by-Step Connection Strength Calculation:
The inclusion of a step-by-step connection strength calculation, complete with **units**, provides a detailed and transparent understanding of the design process.

4 Powered by LaTeX for Readability and Verification:
Leveraging **LaTeX** ensures that all equations are not only easy to read but also verified for accuracy, adding a layer of reliability to the design reports.

These features collectively contribute to making your design reports a **leading** choice in the market, offering a comprehensive, visually informative, and meticulously calculated representation of connection strength in structural designs.

Check moment end plate thickness requirement

Bolt tensile strength

$$\begin{aligned} P_t &= F_t A_b \\ &= 90 \text{ kips}\left(\frac{3.1416(1 \text{ in.})^2}{4}\right) \\ &= 70.69 \text{ kips} \end{aligned}$$

The no prying bolt moment strength

$$\begin{aligned} \phi M_{np} &= \phi 2 P_t (h_0 + h_1) \\ &= 0.75(2)(70.6858 \text{ kips})(22.539 \text{ in.} + 18.017 \text{ in.}) \\ &= 4300 \text{ kip-in.} > M_{uc} = 2200 \text{ kip-in. O.K.} \end{aligned}$$

The end plate yield line mechanism parameter

$$\begin{aligned} s &= \frac{1}{2}\sqrt{b_p g} \\ &= \frac{1}{2}\sqrt{(8.25 \text{ in.})(5.5 \text{ in.})} \\ &= 3.368 \text{ in.} > p_{fi} = 2 \text{ in.} \end{aligned}$$

$$\begin{aligned} Y_p &= \frac{b_p}{2}\left[h_1\left(\frac{1}{p_{fi}} + \frac{1}{s}\right) + h_0\left(\frac{1}{p_{fo}} + \frac{1}{2s}\right)\right] + \frac{2}{g}[h_1(p_{fi} + s) + h_0(d_e + p_{fo})] \\ &= \frac{8.25 \text{ in.}}{2}\left[18.017 \text{ in.}\left(\frac{1}{2 \text{ in.}} + \frac{1}{3.36805 \text{ in.}}\right) + 22.539 \text{ in.}\left(\frac{1}{2 \text{ in.}} + \frac{1}{2(3.36805 \text{ in.})}\right)\right] \\ &\quad + \frac{2}{5.5 \text{ in.}}[18.017 \text{ in.}(2 \text{ in.} + 3.36805 \text{ in.}) + 22.539 \text{ in.}(1.625 \text{ in.} + 2 \text{ in.})] \\ &= 184.4 \text{ in.} \end{aligned}$$

$$\begin{aligned} t_{p,\text{Req'd}} &= \sqrt{\frac{1.11\phi M_{np}}{\phi_b F_{yp} Y_p}} \\ &= \sqrt{\frac{1.11(0.75)(5733.47 \text{ kip-in.})}{0.9(50 \text{ ksi})(184.395 \text{ in.})}} \\ &= 0.7584 \text{ in.} < 0.875 \text{ in. O.K.} \end{aligned}$$

(AISC design guide 4 Equ 3.10)

Figure 4.1 Connection Design Report Example

4.2 Automated 2D Drawings

4.2.1 General Descriptions

The introduction of automatic 2D drawing generation in version V1.5 of our software is a significant advancement (with FreeCAD only). This feature allows users to effortlessly generate member/connection assembly drawings and connection drawings, complete with dimensions and annotations, enhancing the overall design documentation process. Also users can make any changes in these drawings. The provided video link "https://www.youtube.com/watch?v=aRVq2v3a-wk" offers a detailed demonstration of this functionality.

Additionally, the commitment to supporting member drawings in future versions further underscores your dedication to providing comprehensive design solutions and a seamless user experience. This development is sure to benefit users by simplifying the generation of accurate and detailed design documentation.

Currently, we are not supporting 2D drawing automation for Tekla. However, if you have **Premium** subscriptions, we are happy to work with you about the possibilities.

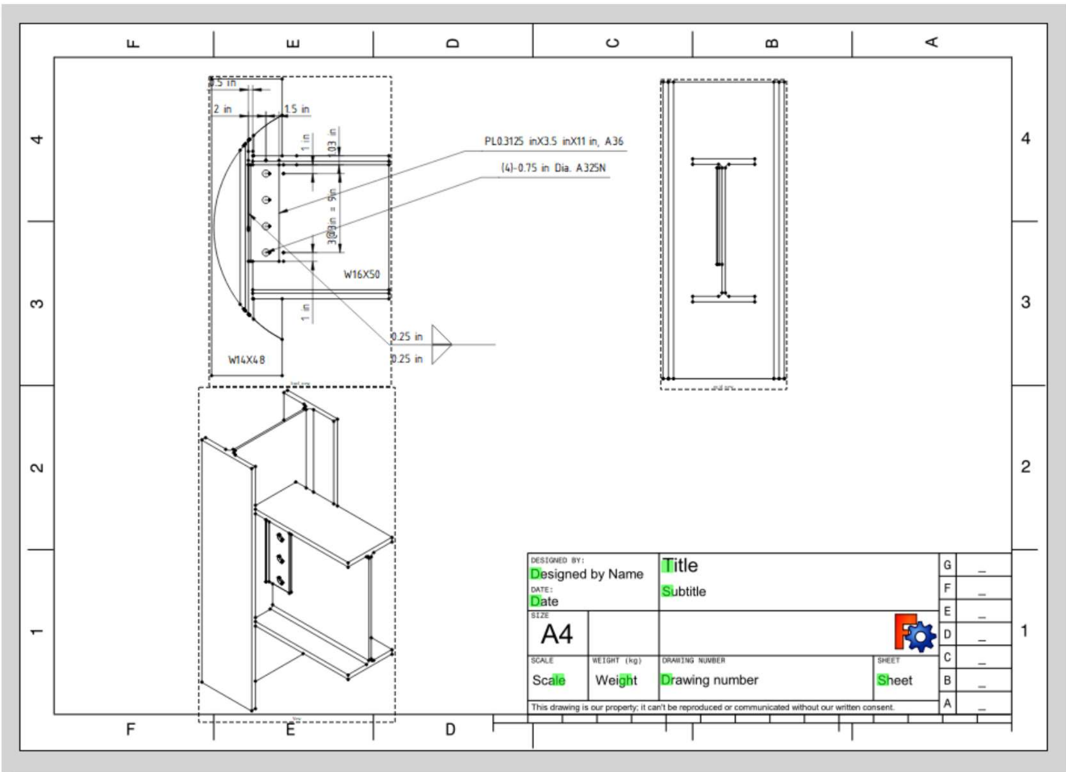

Figure 4.2 Automated 2D Drawing example

4.2.2 FreeCAD Modeling and Drawing Parameter Settings

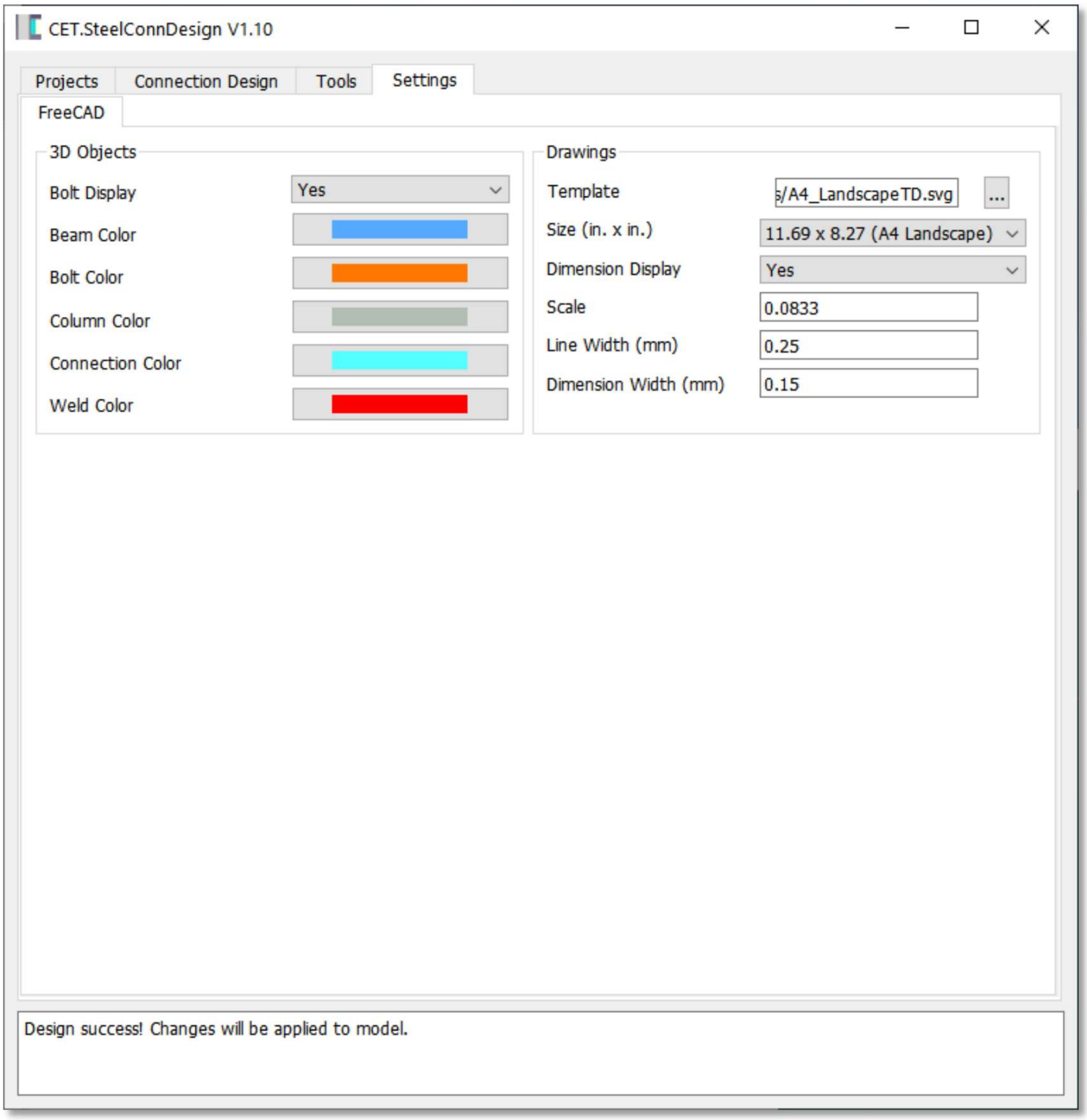

Figure 4.3 FreeCAD Settings in CET.SteelConnDesign

There are many settings user can change (Since Version 1.10):

Bolt Display: CET.SteelConnDesign (since V1.10) supports 3D bolt solids for enhanced model inspection. While these bolt solids do not influence connection design calculations, they are provided to improve visualization. However, generating these bolts in both 3D models and 2D drawings can be time-consuming. This option allows users to choose whether to display bolts or not.

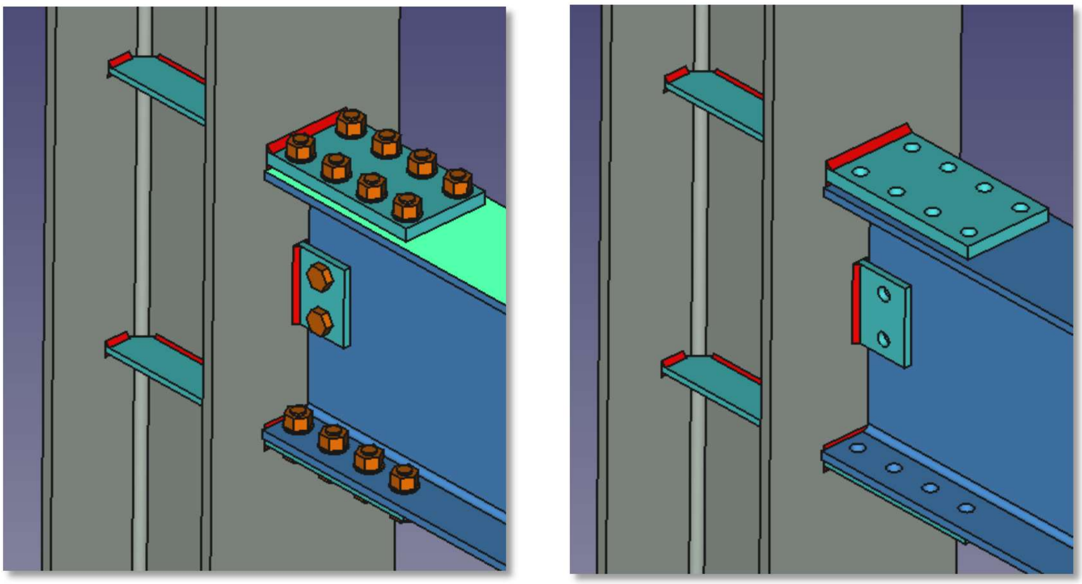

Figure 4.4 3D Model With or Without Bolts

Beam, Bolt, Connection, and Weld Colors: Users can now customize and apply their favorite colors to beams, bolts, connections, and welds.

Template: Users can select their own drawing templates and customize them by adding details such as the company name, author, or other relevant information. For guidance, there are many helpful tutorials available online, such as https://www.youtube.com/watch?v=Tw2ezPZx8rY.

Size: Ensure the selected size matches the dimensions of the chosen template.

Dimension Display: In rare cases, when using the FreeCAD TechDraw workbench, dimensions and annotations may not display correctly in our software. This option allows users to toggle dimensions and annotations on or off, or manually add their own dimensions and annotations as needed.

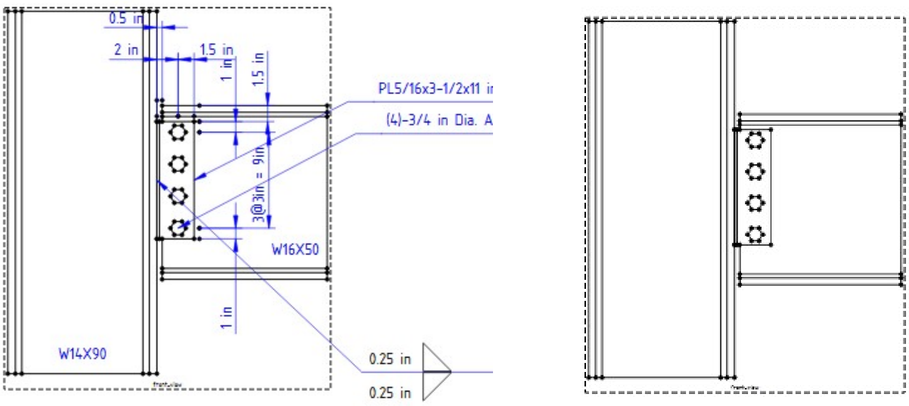

Figure 4.5 Drawings With or Without Dimensions

Scale: This option overrides the "Page Scale" setting in TechDraw Preferences, allowing users to set different scales for different tasks to meet specific requirements.

Line Width: This setting overrides the "Line Width Group" in TechDraw Preferences, offering users more customization options. Note: the value is measured in millimeters.

Dimension Width: Unlike FreeCAD, our software allows users to specify a custom dimension line width, enabling finer control with smaller line widths for detailed drawings.

Additional Settings: In addition to the options mentioned above, users can customize the drawing front size, drawing line color and dimension color directly from the TechDraw workbench.

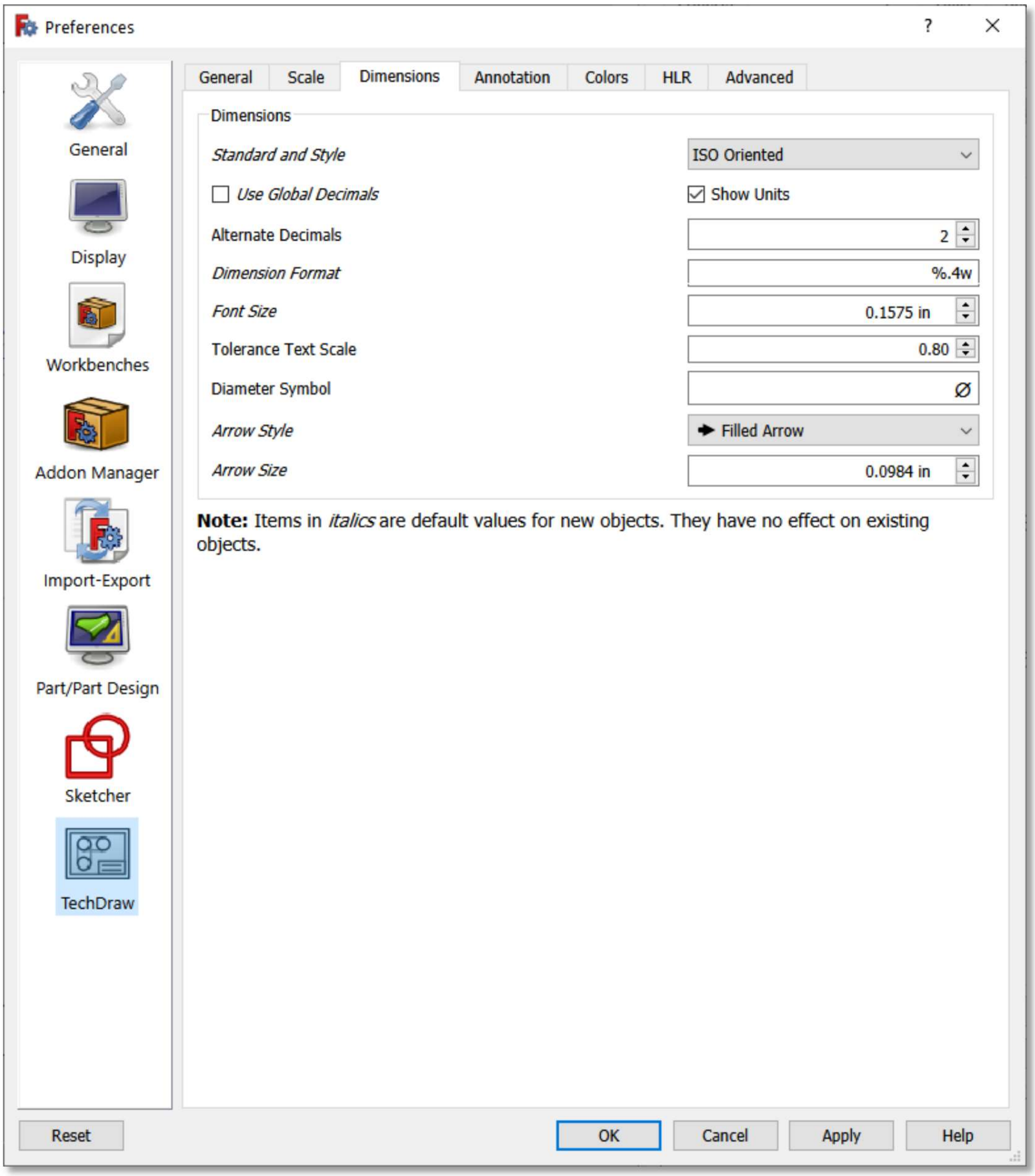

Figure 4.6 Drawing Font Size in Techdraw Settings

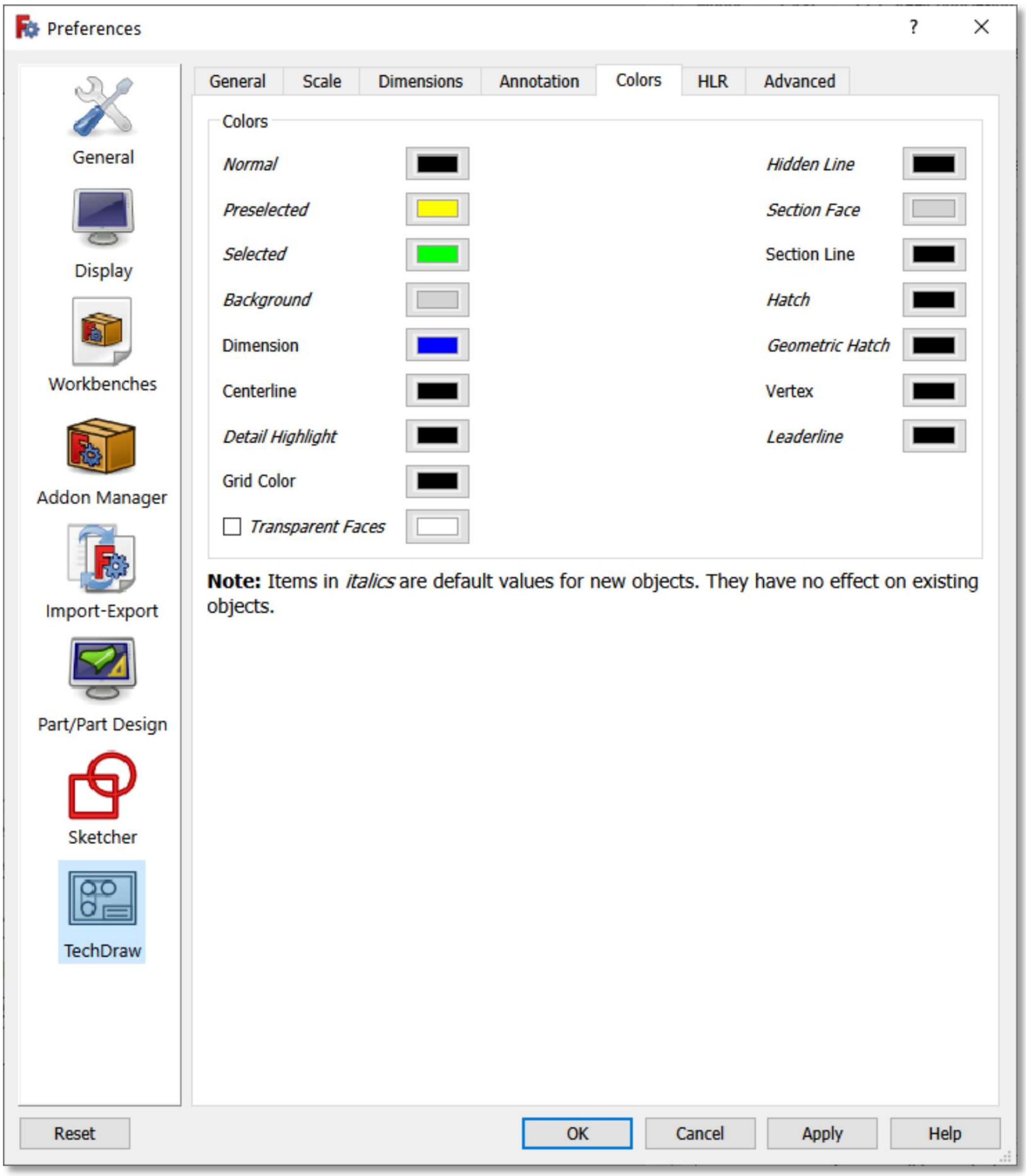

Figure 4.7 Drawing Colors in Techdraw Settings

5 Open-Source Plugins

5.1 General Descriptions

CET.SteelConnDesign embraces open-source principles for engineering and is considering transitioning to an open-source model in the future. The introduction of plugins marks our first step in this direction. This system is designed to provide useful tools that support users in their designs while also enabling them to share their innovative ideas with the community.

The public repository for our plugins is available at https://github.com/CivilEngrTools/SteelConnDesign_plugins. Some plugins, such as the Member Property Plugin, require the "CET_MODULE.cp38-win_amd64.pyd" file, which can be found in the CET.SteelConnDesign installation directory (`C:\Users\<User Name>\AppData\Roaming\CET_SteelConnDesign\`, replacing <User Name> with your actual username). However, this file is **not** required for developing your own plugins.

5.2 Development Setup

5.2.1 Python Environment Setup

Skip this section if **Conda** and **git** are already installed on your computer. Note: This section is specific to Windows OS.

Step 1: Download the Installer

1. Go to the official Anaconda(https://www.anaconda.com/) or Miniconda(https://docs.conda.io/en/latest/miniconda.html) website.
   - Download Anaconda for a full package or Miniconda for a minimal installation.
   - Choose the installer for your system (32-bit or 64-bit).

Step 2: Run the Installer

1. Double-click the downloaded `.exe` file to start the installation.
2. Follow the setup wizard:
   - Agree to the license agreement.
   - Choose "Just Me" (recommended) or "All Users."
   - Select the installation location (default is fine).

Step 3: Configure PATH (Optional)

- When prompted, do not check the option to "Add Anaconda/Miniconda to my PATH environment variable" (recommended).
- Use the Anaconda Prompt or Miniconda Prompt instead to avoid conflicts.

Step 4: Complete Installation

1. Click Install and wait for the process to complete.
2. Launch the Anaconda or Miniconda Prompt from the Start Menu.

Step 5: Verify Installation

1. Open the Anaconda Prompt or Miniconda Prompt.
2. Run: " conda --version"

Step 6: Setup Python 3.8.6

1. Run “conda create -n py38 python=3.8”
2. Run “conda activate py38”

5.2.2 Plugin Development

Step 1: Add Packages to Python

1 Run “conda install git”

2 Run “pip install PySide2”

Step 2: Run Plugins

1 Install CET.SteelConnDesign V1.10 or later version and make sure CET_MODULE.cp38-win_amd64.pyd is in "C:\Users\<User Name>\AppData\Roaming\CET_SteelConnDesign\" directory.

2 In any place run "git clone https://github.com/CivilEngrTools/SteelConnDesign_plugins".

3 In VSCode open the directory created in step 2 and run test_plugins.py

Step 3: Contribute to Code

1 Make sure you have a github account and fork the SteelConnDesign_plugins repository

2 Clone the forked repository to your local directory (different location from Setp2)

3 Create a new branch

4 Create a new plugin or make your changes

5 Commit and push your changes after testing

6 Create a pull request: go to your forked repository on GitHub, click 'Compare & pull request,' add a title and description, ensure the base repository is the original project with 'main' (or 'master') as the base branch, and submit it.

7 Once your pull request is approved, your plugins will appear in the next release. However, you still can use them locally. Please see step 4.

Step 4: Update Plugins

1. If you have developed your own plugins, you can copy them to the following directory after testing: `C:\Users\<User Name>\AppData\Roaming\CET_SteelConnDesign\plugins`. Your plugin will be automatically loaded when you run CET.SteelConnDesign and will appear in the plugins dropdown list. Please refer to section 5.2.3 for details on the required file structure.
2. To update plugins, you can run the following command in the plugin installation directory: `git pull https://github.com/CivilEngrTools/SteelConnDesign_plugins`.

5.2.3 Plugin Structure

Plugins are structured using folders and files, where the folder name corresponds to the plugin name displayed in the plugin dropdown list. Each plugin folder must include a **plugin.py** file. In this file, you need to specify the “author”, “description”, “category”, and “load_order” fields, and ensure the class is named “PluginUI(QWidget)”.

```
----Member_Property
  |----plugin.py
---Nominal_Hole_Dimension
  |----plugin.py
```

Figure 5.1 Plugin File Structure

5.3 Plugins

5.3.1 Member Property

This plugin allows users to quickly check member properties without referring to book tables. It currently supports AISC 13th, 14th, and 15th edition shape data, including W-shapes, angles, and rectangular HSS shapes.

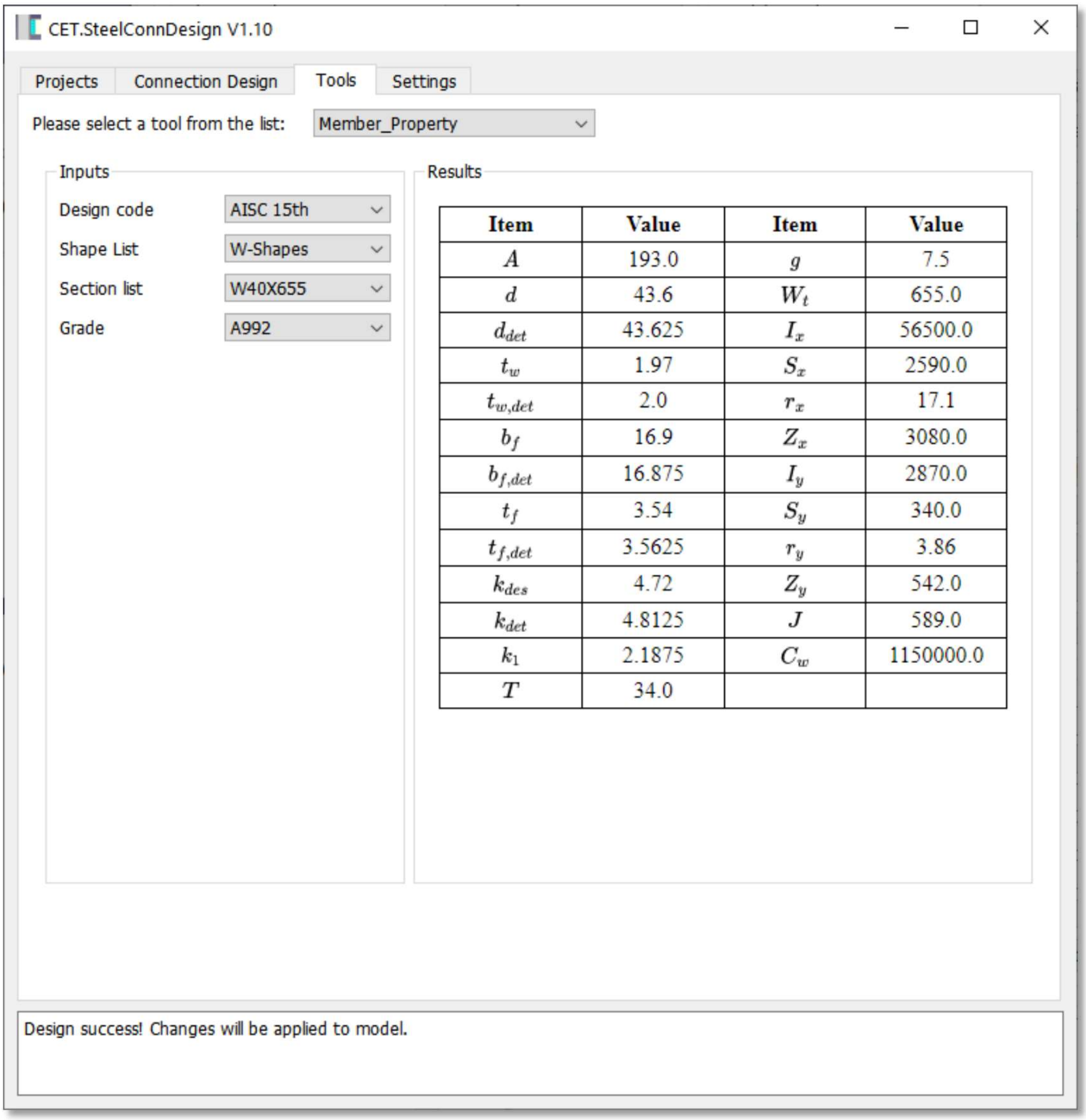

Figure 5.2 Member Property Plugin

5.3.2 Nominal Hole Dimension

This plugin calculates hole dimensions based on AISC 13th, 14th, and 15th editions, referencing Tables J3.3 and J3.3M. It supports both imperial and metric units and accommodates standard, oversized, and slotted holes. Additionally, it provides a visual representation of slotted hole dimensions.

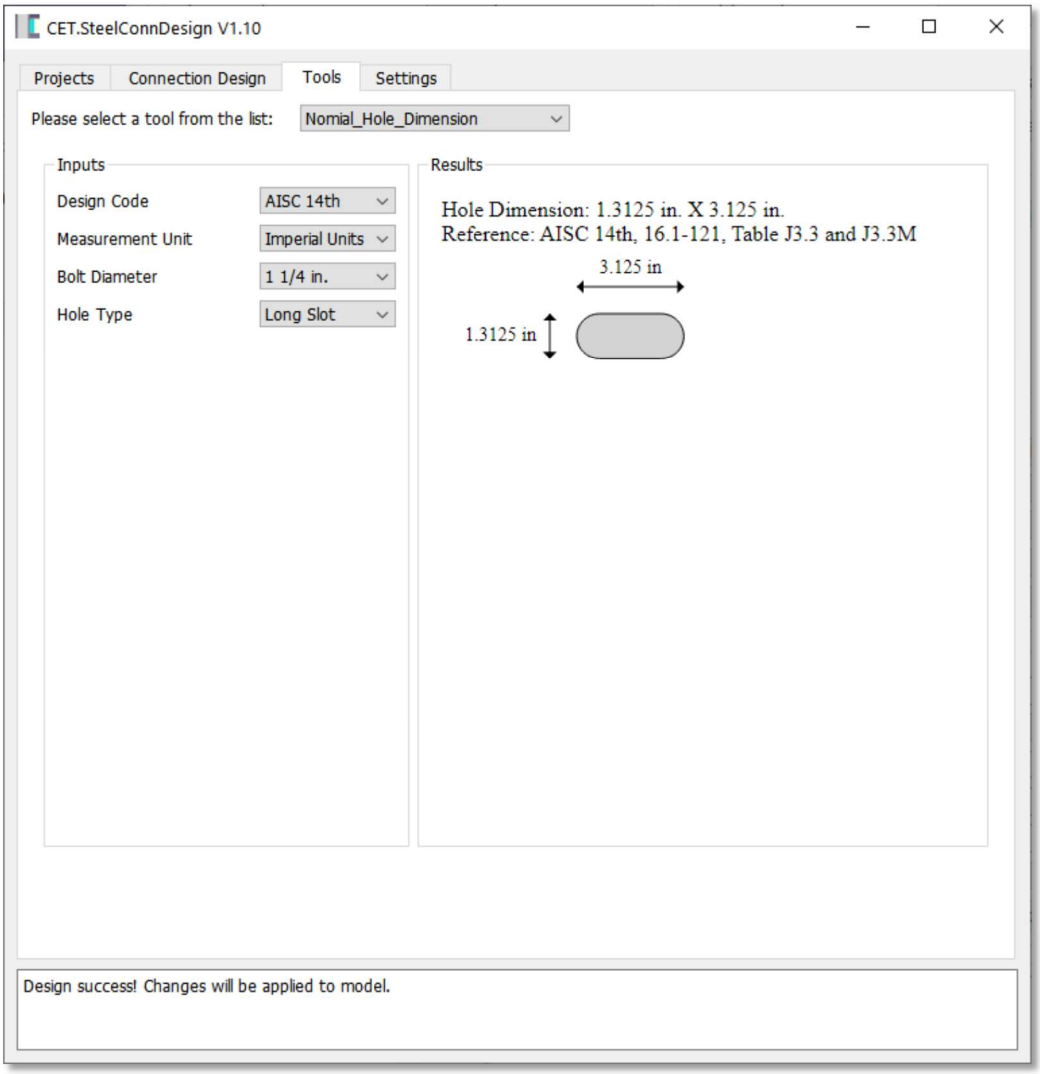

Figure 5.3 Nominal Hole Dimension Plugin

6 Verification Problems

6.1 All-Bolted Double-Angle Connection Subject to Axial and Shear Loading, AISC Design Example V15.0

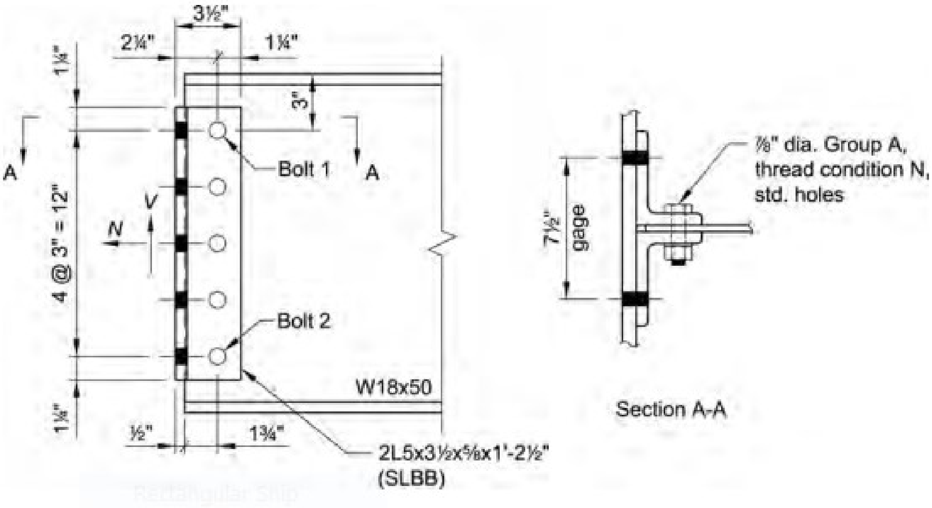

Figure 6.1 All-Bolted Double-Angle Connection Subject to Axial and Shear Loading (Photo Credit: AISC)

This example is from AISC Design Example V15.0 II.A-1B. Please check the model file in Github (https://github.com/CivilEngrTools/SteelConnDesign/blob/main/Verification_Problems/AISC15_II_A-1B.bpj). Results:

Table 6.1 Results Comparison for All-Bolted Double-Angle Connection Subject to Axial and Shear Loading

Location	Item	AISC Design Example Results	CET.SteelConnDesign Results	Difference
Beam Web	Shear Yielding	128 Kips	127.8 Kips	0.16 %
	Tensile Yielding	440 Kips	440.1 Kips	0.02 %
	Tensile Rupture	171 Kips	171 Kips	0.0 %
	Block Shear U shape, Axial Force	106 Kips	106.1 Kips	0.09 %
	Bolt Shear	163 Kips	162.4 Kips	0.37 %
Angle Web Leg	Shear Yielding	261 Kips	261 Kips	0.0 %
	Shear Rupture	207 Kips	206.6 Kips	0.19 %
	Tensile Yielding	390 Kips	390.7 Kips	0.18 %
	Tensile Rupture	345 Kips	344.4 Kips	0.17 %
	Block Shear L shape, Shear Force	207 Kips	206.1 Kips	0.43 %
	Block Shear L shape, Axial Force	333 Kips	333.5 Kips	0.15 %
	Block Shear U shape, Axial Force	323 Kips	322.6 Kips	0.12 %
	Block Shear Interaction	0.0737	0.0742	0.68 %
	Block Shear	213 Kips	212.5 Kips	0.12 %

Angle OSL	Bolt in Tension	268 Kips	268.4 Kips	0.15 %
	Bolt Prying	58.7 Kips	58.4 Kips	0.5 %

Note:
1) Bearing and weld calculation details are not compared in this table.

6.2 Single-Plate Connection Subject to Axial and Shear Loading (Beam-to-Column Flange), AISC Design Example V15.0

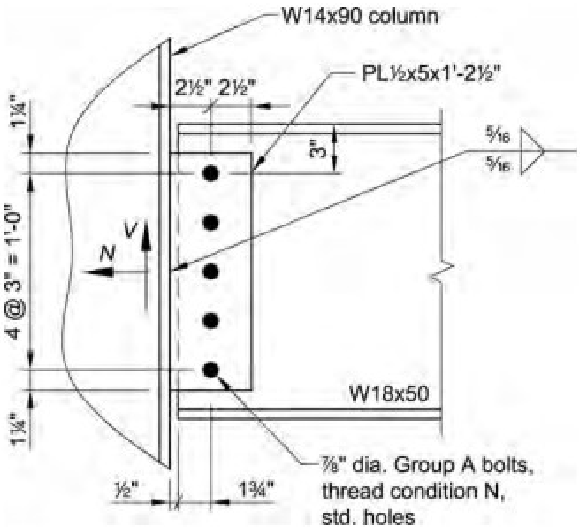

Figure 6.2 Single-Plate Connection Subject to Axial and Shear Loading (Beam-to-Column Flange) (Photo Credit: AISC)

This example is from AISC Design Example V15.0 II.A-17B. Please check the model file in Github (https://github.com/CivilEngrTools/SteelConnDesign/blob/main/Verification_Problems/AISC15_II_A-17B.bpj). Results:

Table 6.2 Results Comparison for Single-Plate Connection Subject to Axial and Shear Loading (Beam-to-Column Flange)

Location	Item	AISC Design Example Results	CET.SteelConnDesign Results	Difference
Beam Web	Shear Yielding	128 Kips	127.8 Kips	0.16 %
	Tensile Yielding	440 Kips	440.1 Kips	0.02 %
	Tensile Rupture	171 Kips	171 Kips	0.0 %
	Block Shear U shape, Axial Force	106 Kips	109.6 Kips	3.4 % (1)
	Bolt Shear	74.5 Kips	74.55 Kips	0.07 %
Single Plate	Shear Yielding	145 Kips	145 Kips	0.0 %
	Shear Rupture	92.5 Kips	92.6 Kips	0.11 %
	Flexural Yielding	316 Kips	314.7 Kips	0.41 %
	Interaction of axial, flexural and shear yielding	0.148	0.148	0.0 %
	Tensile Yielding	217 Kips	217.1 Kips	0.05 %

	Tensile Rupture	155 Kips	155.4 Kips	0.39 %
	Flexural Rupture	316 Kips	314.7 Kips	0.41 %
	Interaction of axial, flexural and shear rupture	0.42	0.42	0.0 %
	Block Shear L shape, Shear Force	118 Kips	117.8 Kips	0.17 %
	Block Shear L shape, Axial Force	161 Kips	160.9 Kips	0.06 %
	Block Shear U shape, Axial Force	168 Kips	167.5 Kips	0.30 %
	Block Shear Interaction	0.241	0.242	0.41 %

Note:
1) In the calculation of beam web block shear (U-shape), the AISC Design Example uses a beam edge distance leh = 1.75 inches, whereas CET.SteelConnDesign uses 2 inches, resulting in a 3.4% difference. Based on the drawing, our results appear to be reasonable.
2) Bearing and weld calculation details are not compared in this table.

6.3 Bolted Flange-Plated FR Moment Connection (Beam-to-Column Flange), AISC Design Example V15.0

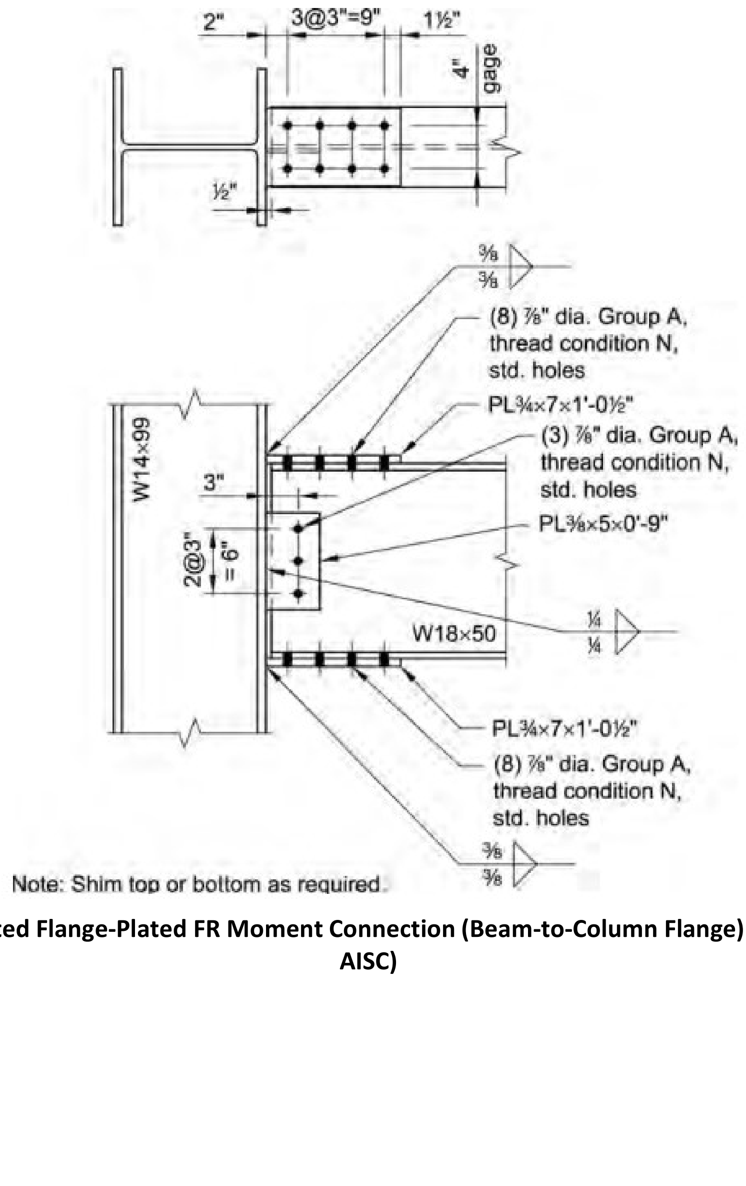

Figure 6.3 Bolted Flange-Plated FR Moment Connection (Beam-to-Column Flange) (Photo Credit: AISC)

This example is from AISC Design Example V15.0 II.B_1. Please check the model file in Github (https://github.com/CivilEngrTools/SteelConnDesign/blob/main/Verification_Problems/AISC15_II_B-1.bpj). Results:

Table 6.3 Results Comparison for Bolted Flange-Plated FR Moment Connection (Beam-to-Column Flange)

Location	**Item**	**AISC Design Example Results**	**CET.SteelConnDesign Results**	**Difference**
Beam Web	Shear Yielding	N/A	127.8 Kips	N/A
	Bolt Shear	45.9 Kips	48.71 Kips	6.12 % (1)
Single Plate at Beam Web	Shear Yielding	48.7 Kips	48.6 Kips	0.21 %
	Shear Rupture	39.2 Kips	39.15 Kips	0.13 %
	Block Shear	46.7 Kips	46.69 Kips	0.02 %
Beam Flange	Flexural Strength	140.67 Kips	141 Kips	0.23 %
	Block Shear	197 Kips	196.4 Kips	0.30 %
Flange Plate at Beam Flange	Tensile Yielding	113 Kips	113.2 Kips	0.18 %
	Tensile Rupture	109 Kips	108.8 Kips	0.18 %
	Block Shear (2L shape)	213 Kips	213.6 Kips	0.28 %
	Block Shear (L shape)	172 Kips	172.1 Kips	0.06 %
	Buckling	113 Kips	113.2 Kips	0.18 %
Column	Flange Bending	114 Kips	113.8 Kips	0.18 %
	Web Crippling	155 Kips	158.8 Kips	2.45 % (2)
	Web Local Yielding	124 Kips	128 Kips	3.23 % (2)

Note:

1) The AISC Design Example combines bolt shear and bearing calculations, whereas CET.SteelConnDesign separates them.
2) For column web crippling and local yielding capacity calculations, CET.SteelConnDesign accounts for the presence of welds when calculating lb value, resulting in slightly higher capacities.
3) Bearing and weld calculation details are not compared in this table.

Reference

AISC Steel Construction Manual, 13th Ed
AISC Steel Construction Manual, 14th Ed
AISC Steel Construction Manual, 15th Ed
AISC Design Example Version 13.0
AISC Design Example Version 14.0
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