User Manual

By CivilEngrTools.com

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Catalog

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 tailored exclusively for Windows OS and is compatible solely with Imperial units. Notably, it is not an open-source program, though we willingly share the source code with our partners upon request.

While **CET.SteelConnDesign** is available for free, we encourage users to explore the enhanced features of our Premium service. To access Premium benefits, kindly contact **civilengrtools@gmail.com** for additional details. Premium users can relish 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.

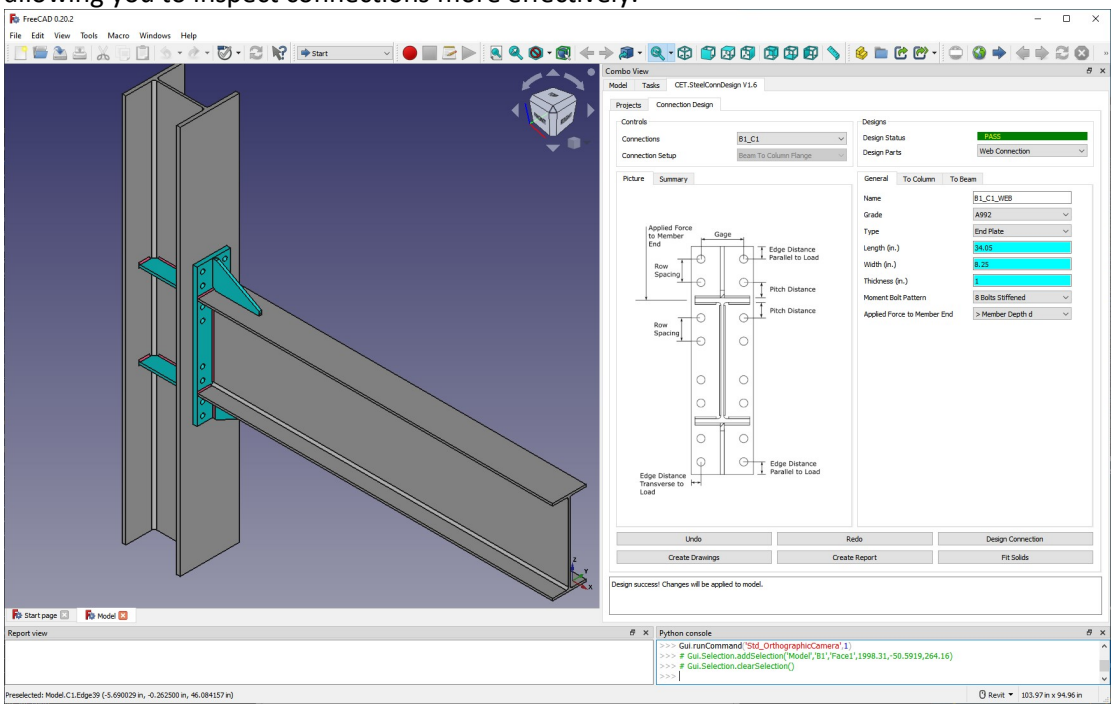

Figure 1 Inspection 3D model in CET.SteelConnDesign with FreeCAD

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

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

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

Check column web local yielding

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

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

Check column web crippling

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

Figure 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).

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.

1.6 Version History

Table 1 CET.SteelConnDesign Version History

Version Number	Notes
V1.7	1 Support **beam splice** connections 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 falnge, **moment flange plate** connection
V1.0	First Release: Beam to column **single plate** connection

1.7 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. In the long term, our goals include:

- Expanded design codes support
- Integration of seismic design
- Implementation of **AI** for connection design
- Import IFC models

1.8 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

2.3.2 Setup FreeCAD for CET.SteelConnDesign

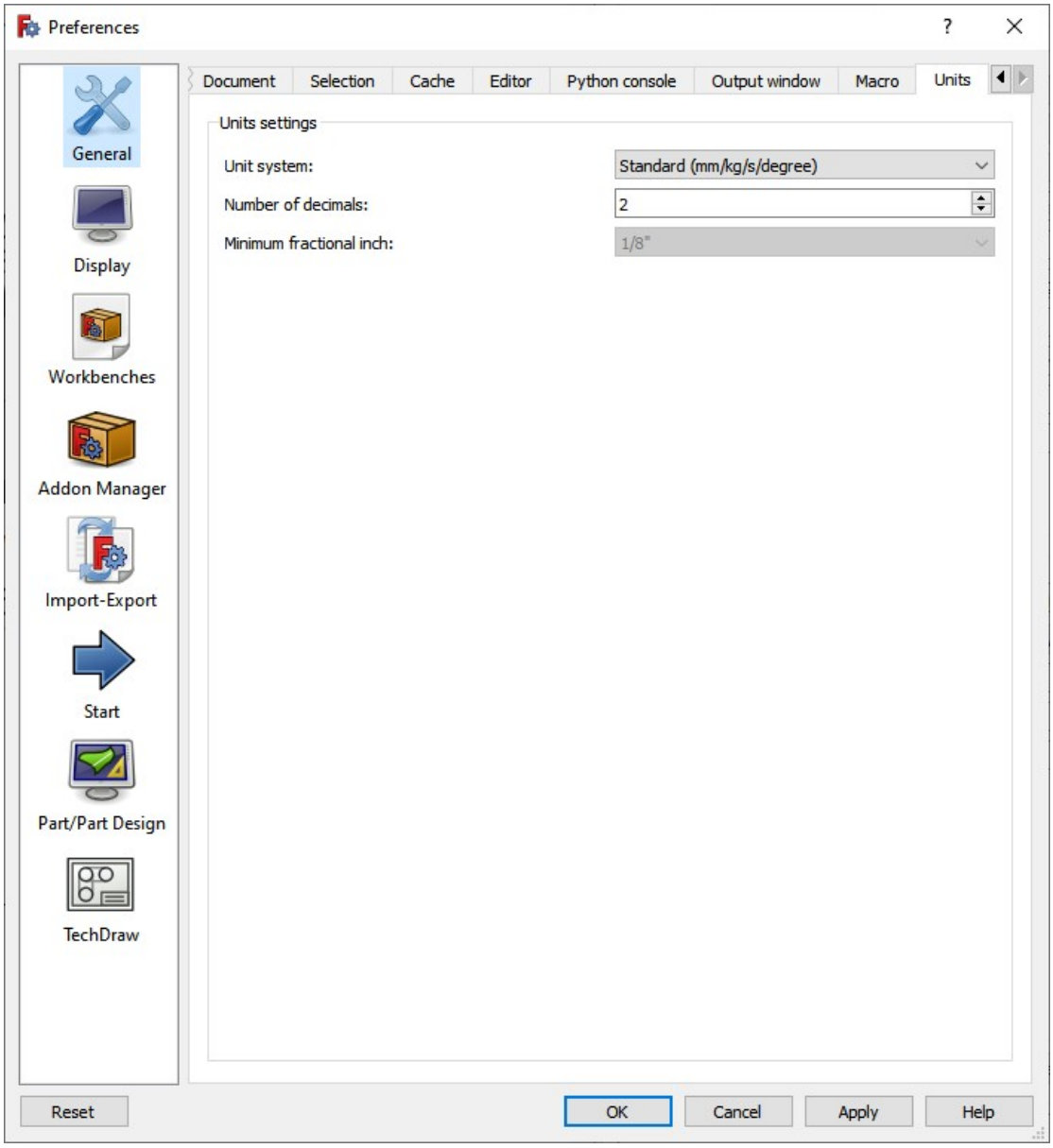

Figure 3 FreeCAD setup, units

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

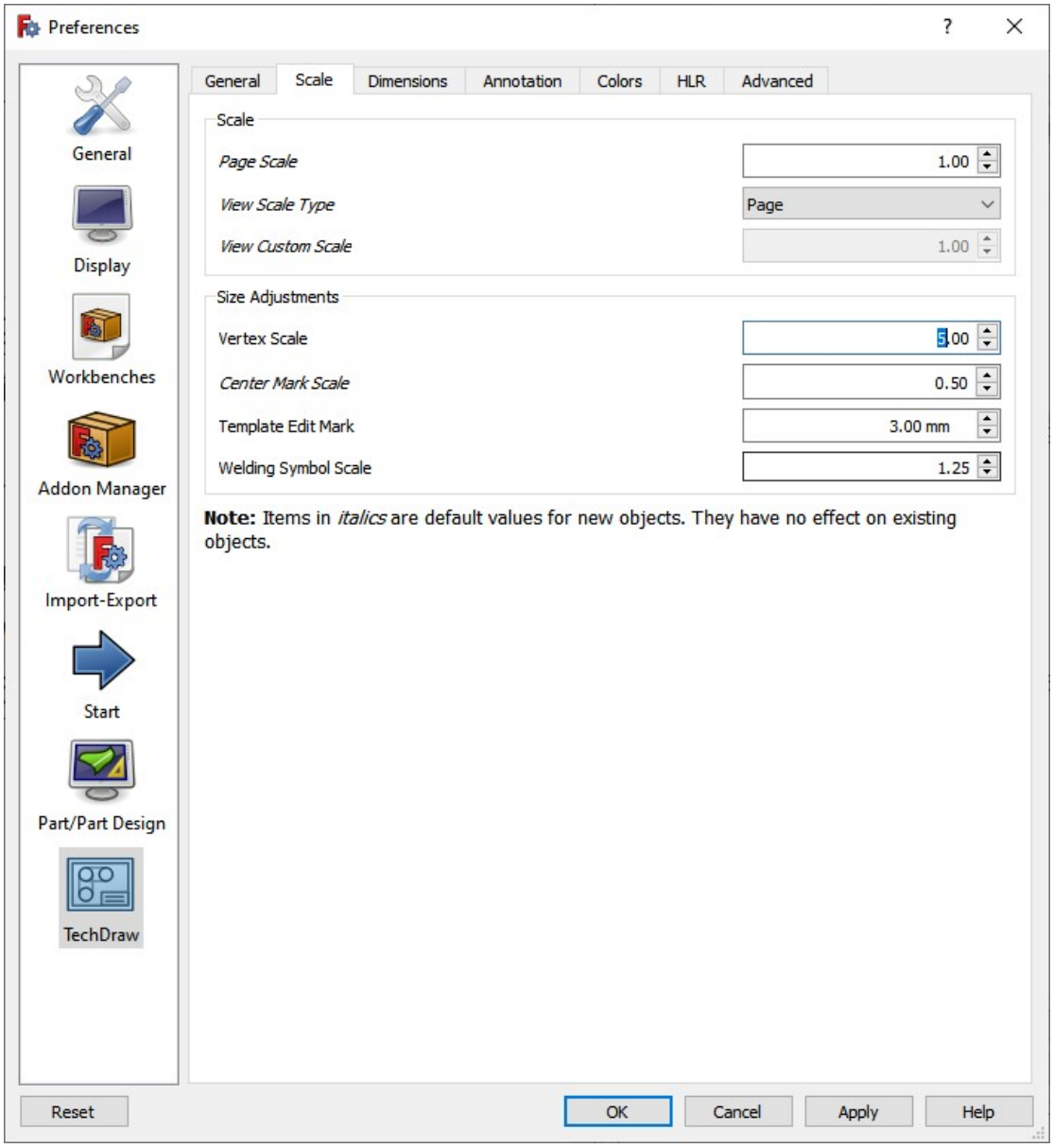

Figure 4 FreeCAD setup, scale

1 Change “Vertex Scale” to 3.0
2 change “Welding Symbol Scale” to 1.0

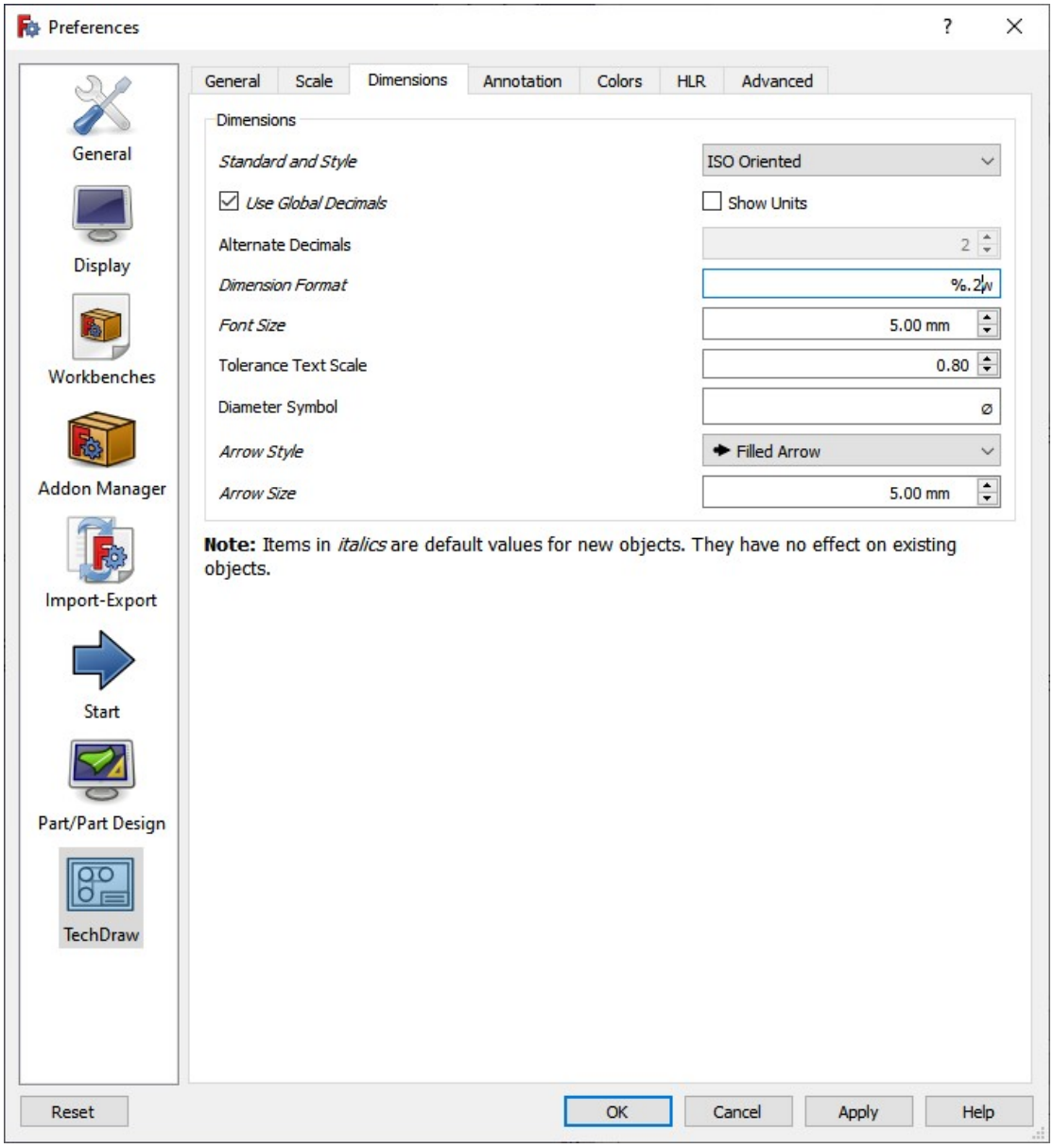

Figure 5 FreeCAD setup, dimension

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

2.4 Using CET.SteelConnDesign with Tekla

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 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, for tutorial videos.

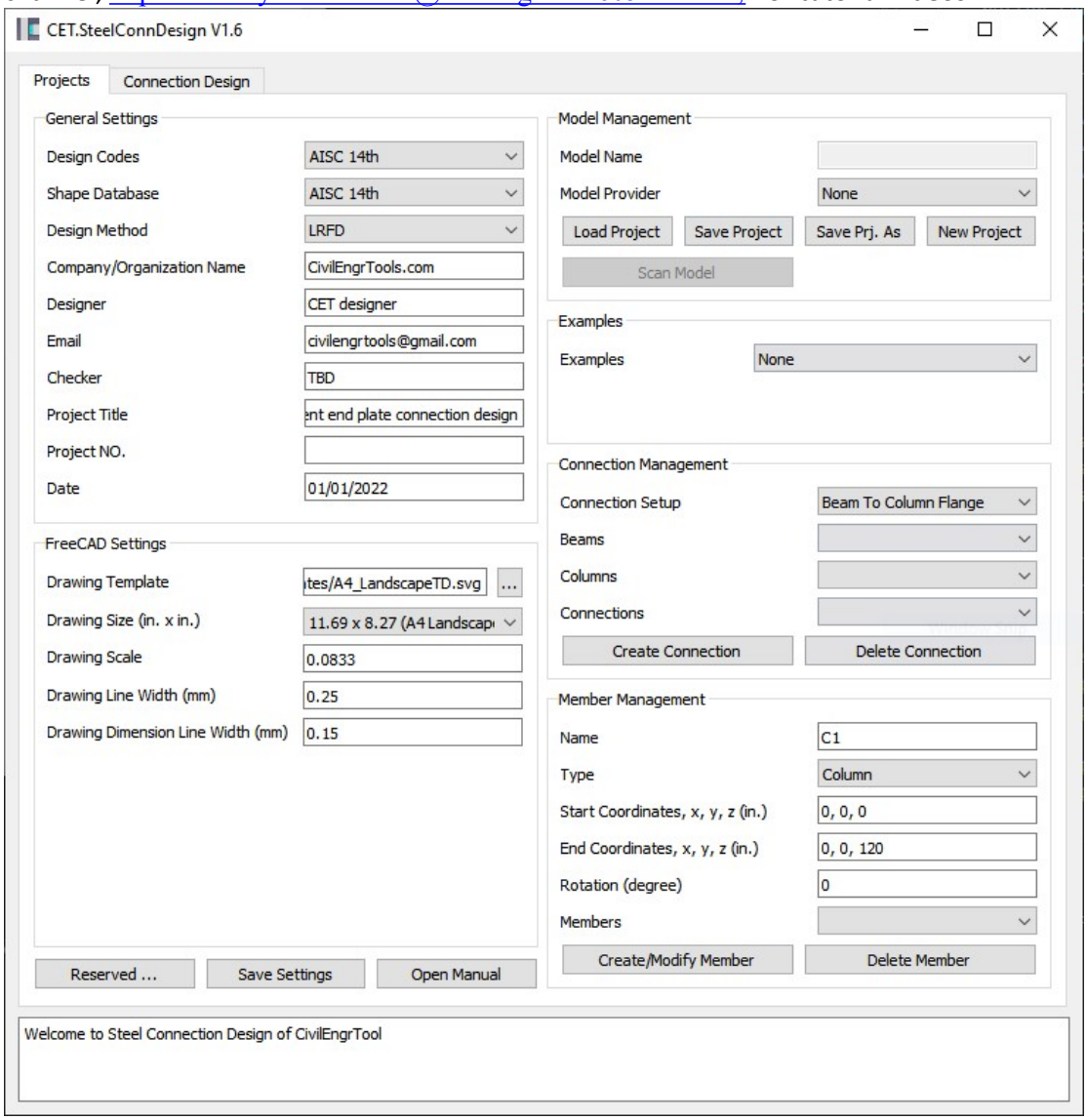

Figure 6 UI, Project tab

Figure 7 UI, Connection Design tab

2.5.2 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.

2.5.3 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 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

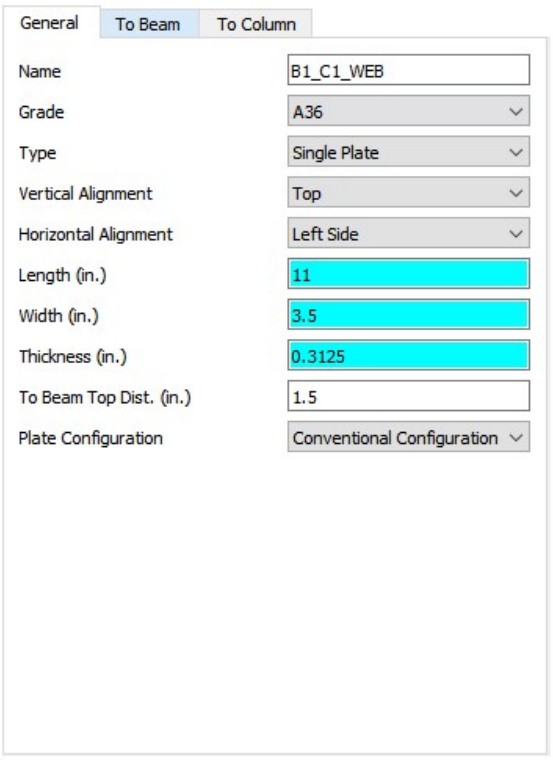

Figure 8 System-designed values highlighted in a cyan color

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.

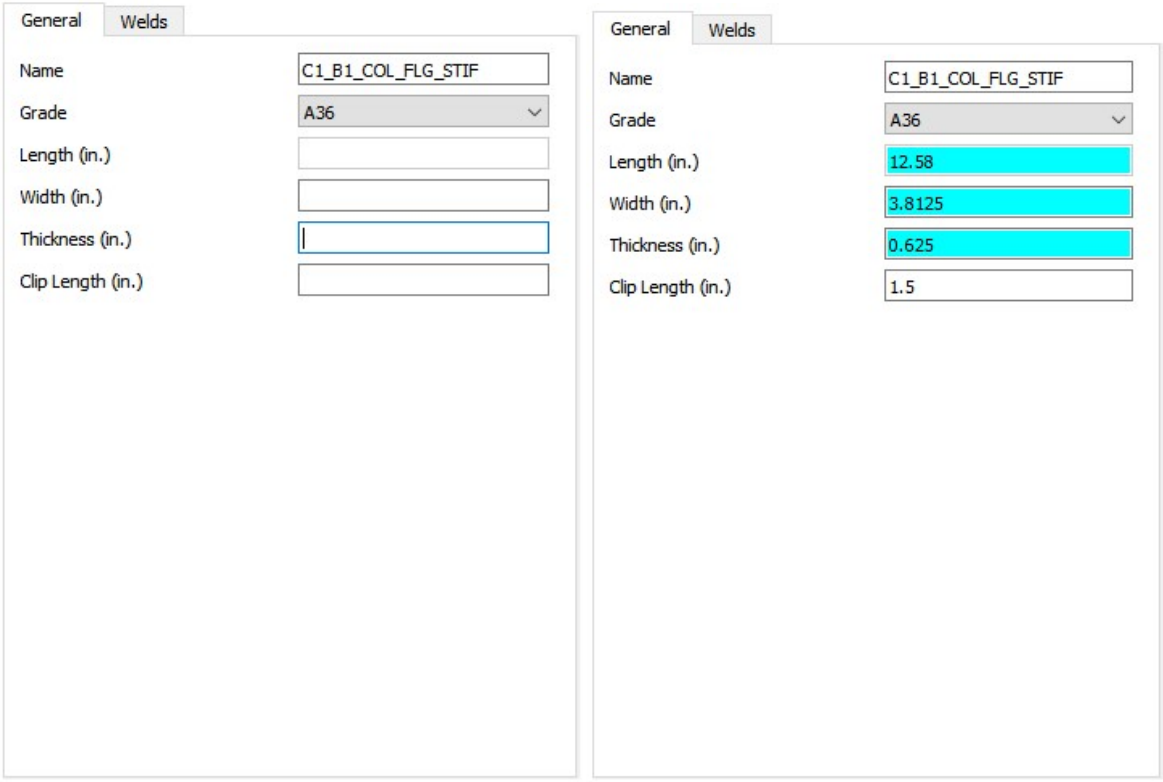

Figure 9 User input clip length will trigger the column transverse stiffener design

2.5.4 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.

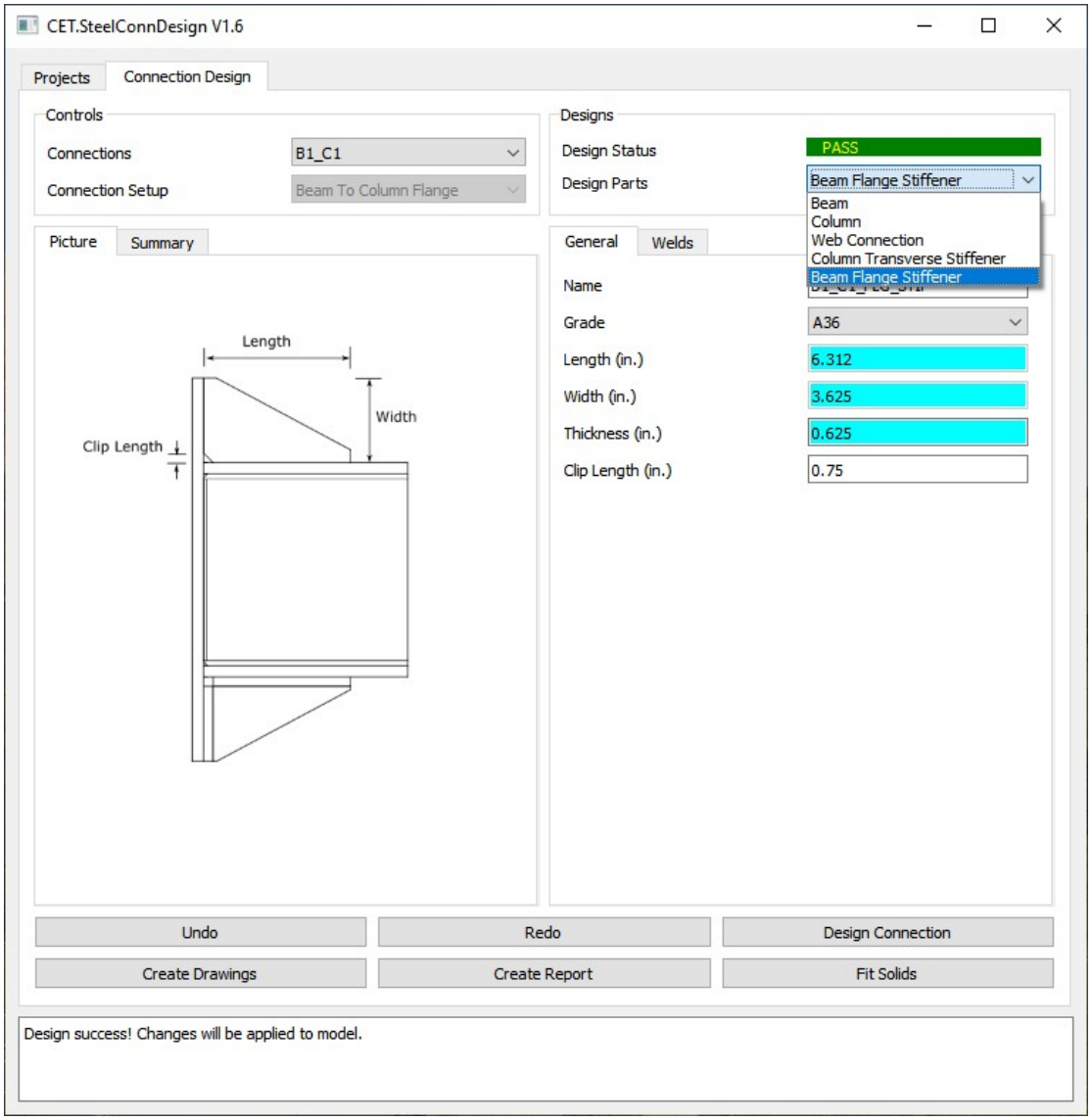

Figure 10 Switch between design parts

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 and moments. Refer to the table below for a detailed overview:

Table 3 Force, 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	No

3.1.1 Beam To Column Flange/Web

(No content)

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

3.1.3 Beam Splice

Important points to consider:

1. Ensure that the both beams shares the same top elevation.
2. Do not support moment

3.2 General Connection Design

3.2.1 Bolt Design

Please see AISC Specification J3.

3.2.2 Weld Design

Please see AISC Specification J2.

3.2.3 Bolt Spacing and Edge Distance

Please see AISC Specification J3.

3.2.4 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)

3.2.5 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.

3.2.6 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.

3.2.7 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 encompasses examinations for both flexural strength and flexural local buckling strength.

3.3.2 Beam Flange

(no content)

3.3.3 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

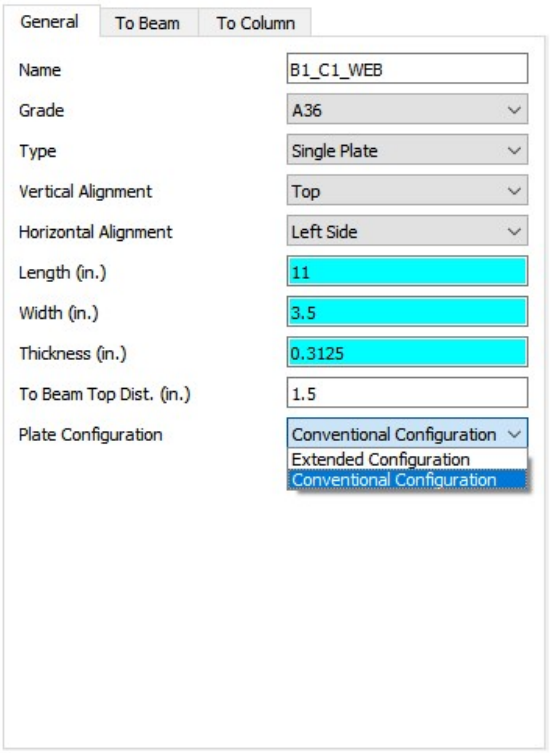

Figure 11 "Plate Configuration" dropdown in single plate connection design

3.3.4 End Plate Connection

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

3.3.5 Moment End Plate Connection

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

3.3.6 Column Transverse Stiffener

(Coming soon)

3.3.7 Beam Flange Stiffener

(Coming soon)

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.

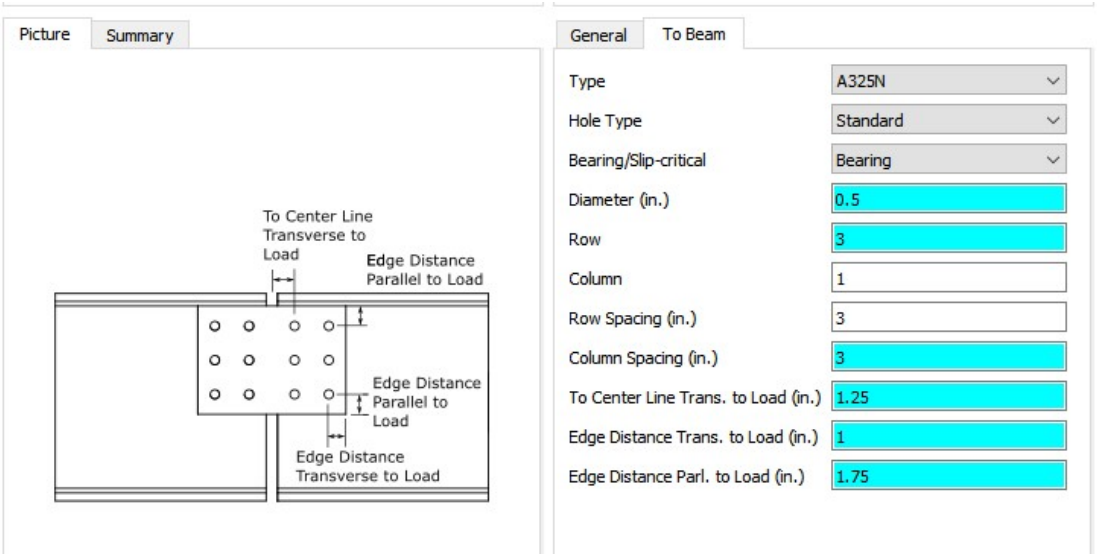

Figure 12 Inputs for Beam Splice Connection

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

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.

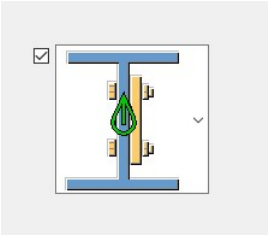

Figure 13 Tekla Plate Side for Beam Splice Connection

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 14 Connection Design Report Example

4.2 Automated 2D Drawings with FreeCAD

4.2.1 General

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.

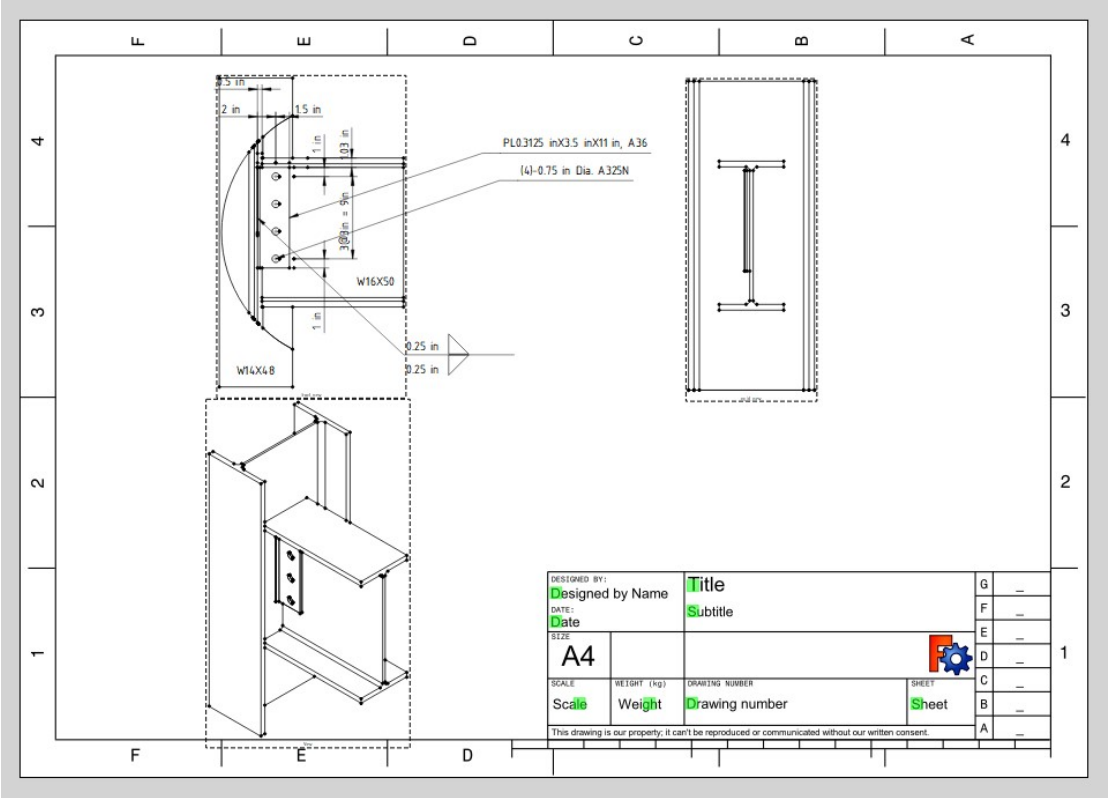

Figure 15 Automated 2D Drawing example

4.2.2 Drawing Parameter Settings

(Coming soon)

Reference

AISC Steel Construction Manual, 13th Ed
AISC Steel Construction Manual, 14th Ed
AISC Steel Construction Manual, 15th Ed
AISC Design Guide 4: Extended End-Plate Moment Connections Seismic and Wind Applications