US Webinar

Design of steel to concrete connections, including base plates

June 28
12pm EST

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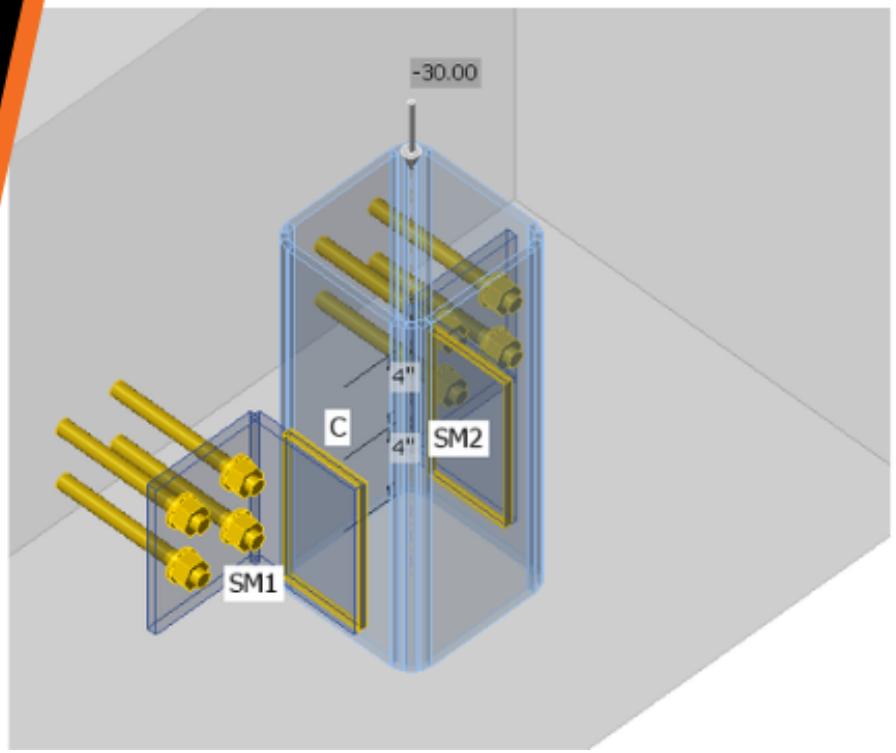

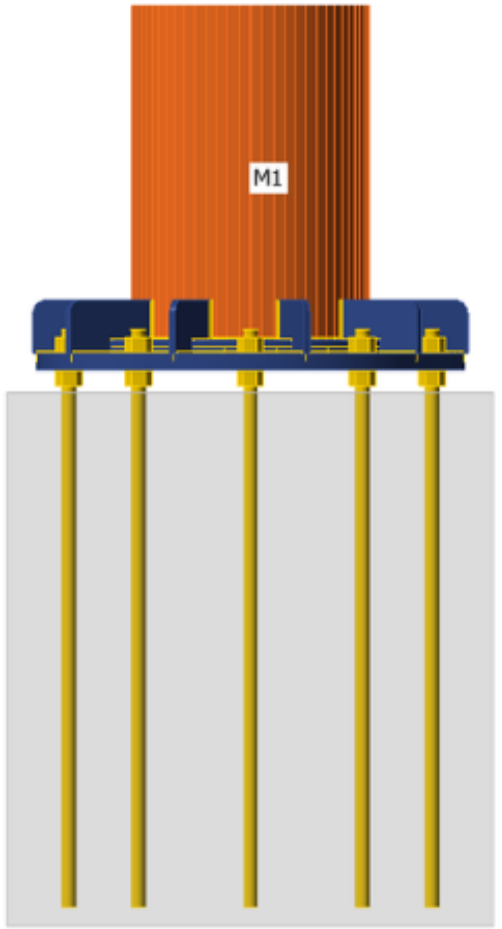

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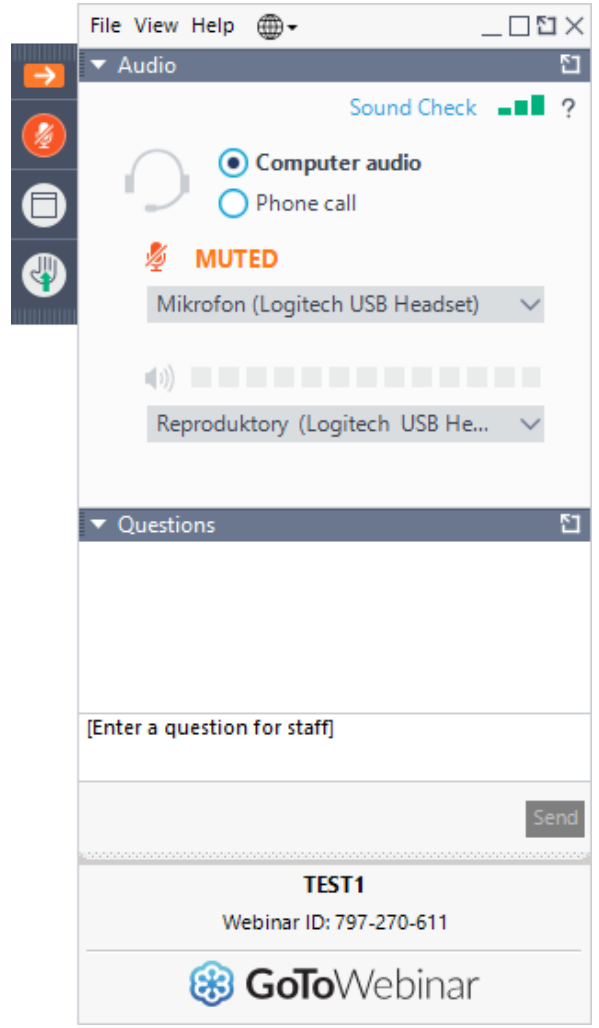
- **Grab Tab**: From the Grab Tab, you can hide the Control Panel, mute yourself (if you have been unmuted by the organizer), view the webinar in full screen and raise your hand.
- **Audio Pane**: Use the Audio pane to switch between Telephone and Mic & Speakers.
- **Questions Pane**: Ask questions for the staff.

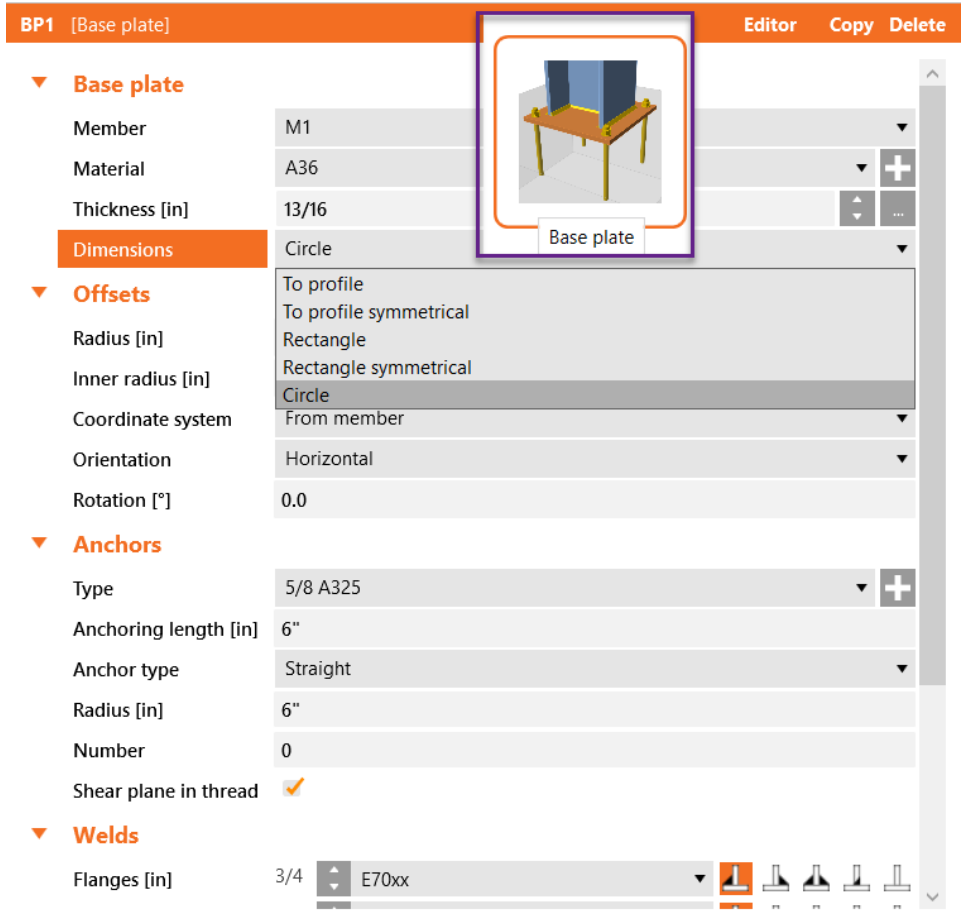
QUESTIONS



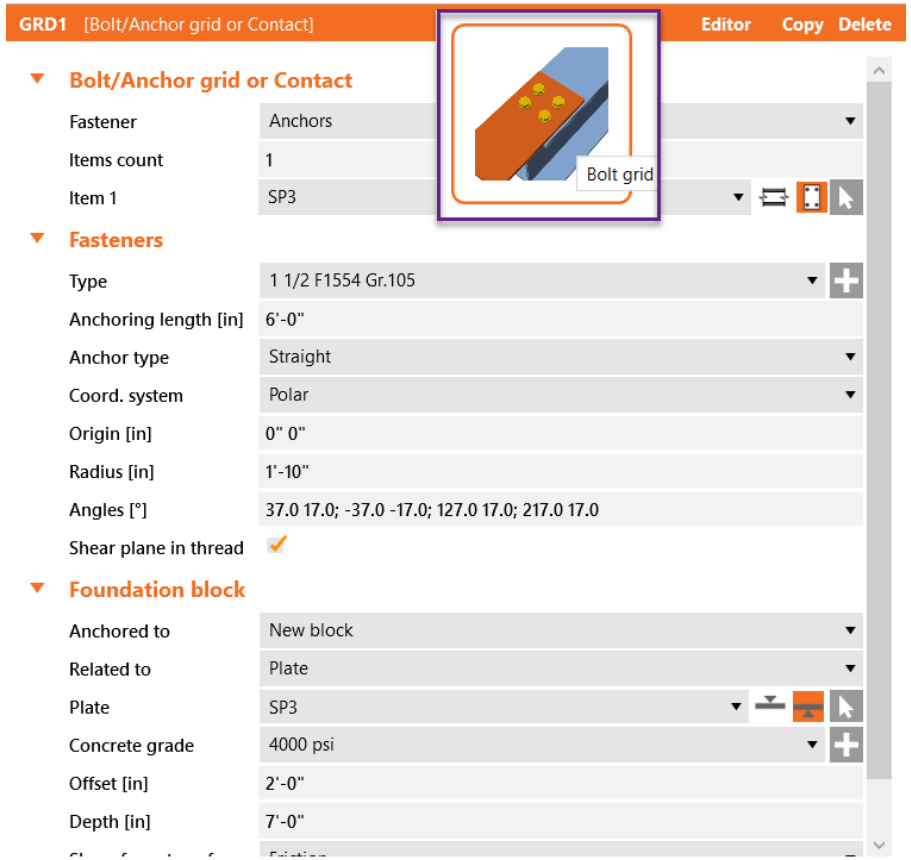
Agenda

- Base plate vs Anchor Grid operation – Modeling examples
- Anchor and concrete block analysis and code checks
- Contact and weld simultaneously, contact only
- Verification study
- Limitations

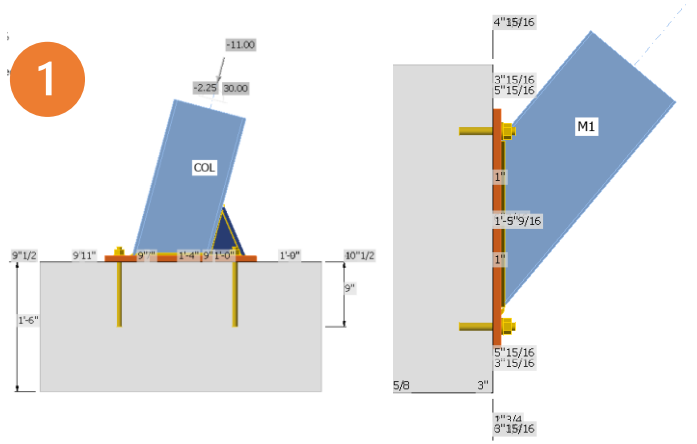
Base plate



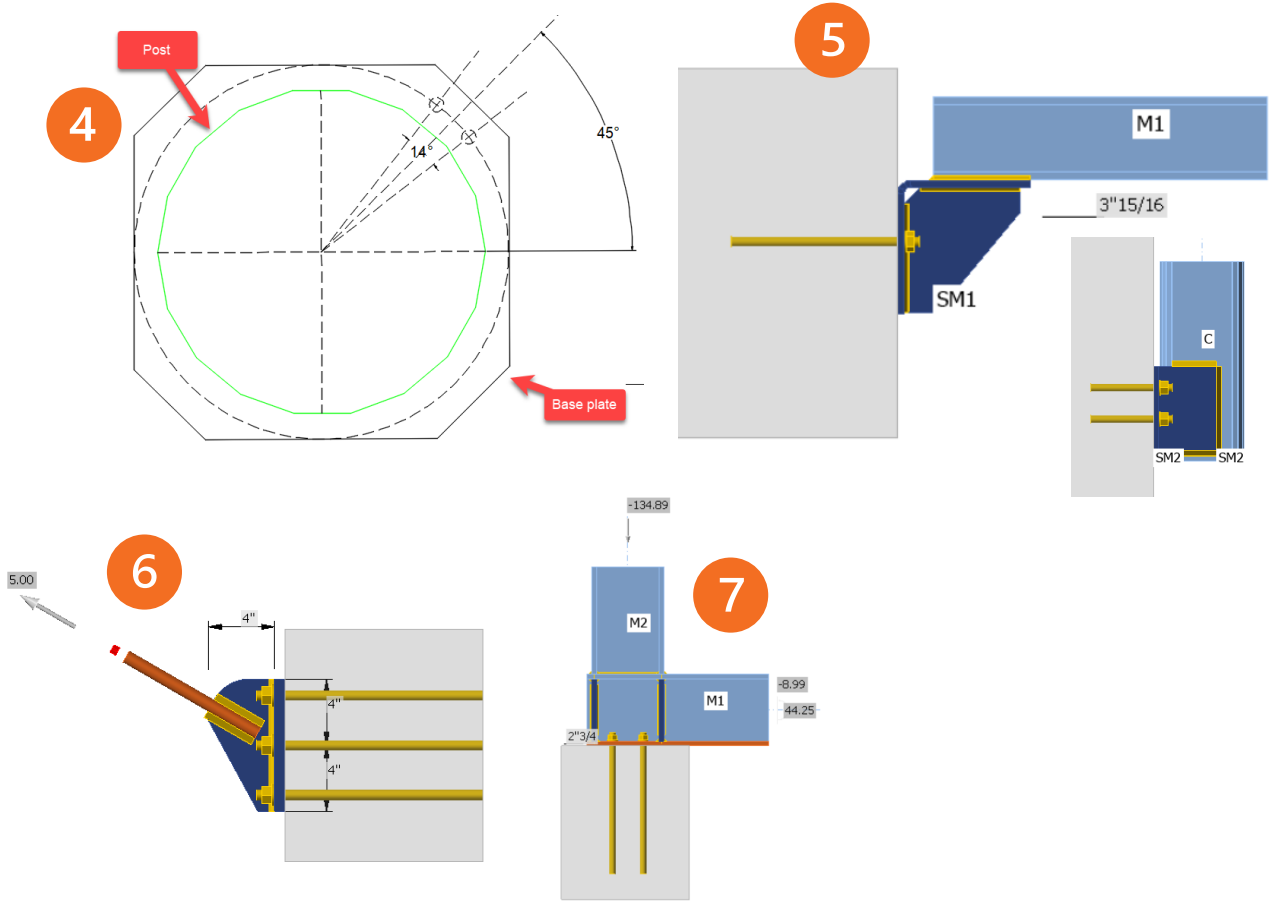
Anchor grid operation



Practical examples

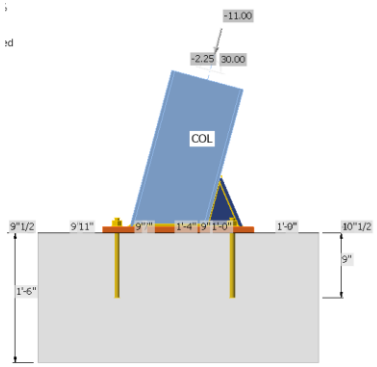


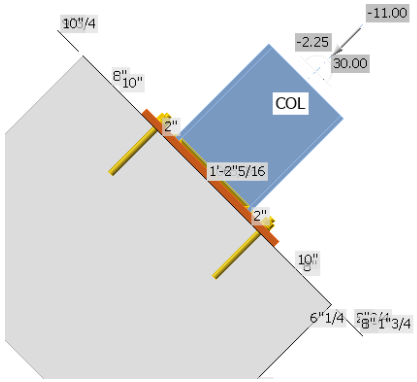
Base plate operation

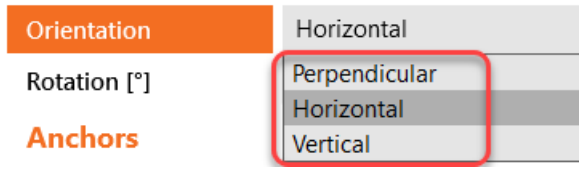


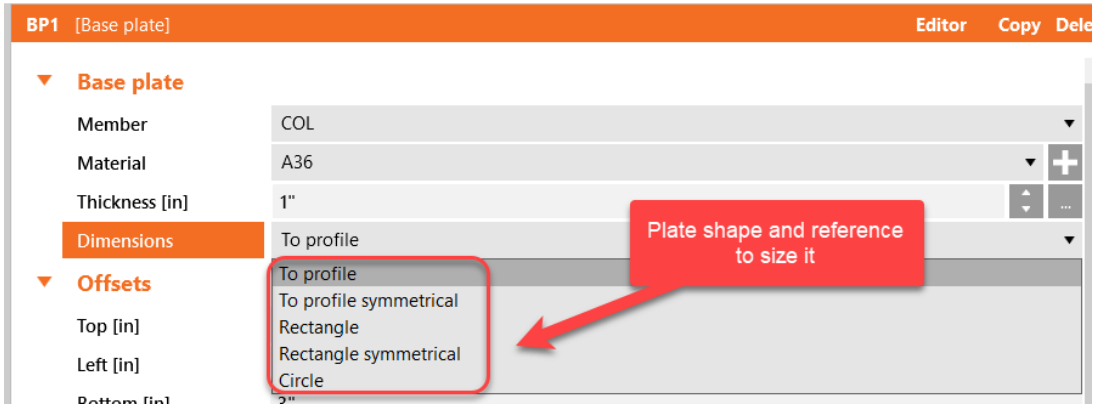
Anchor grid operation

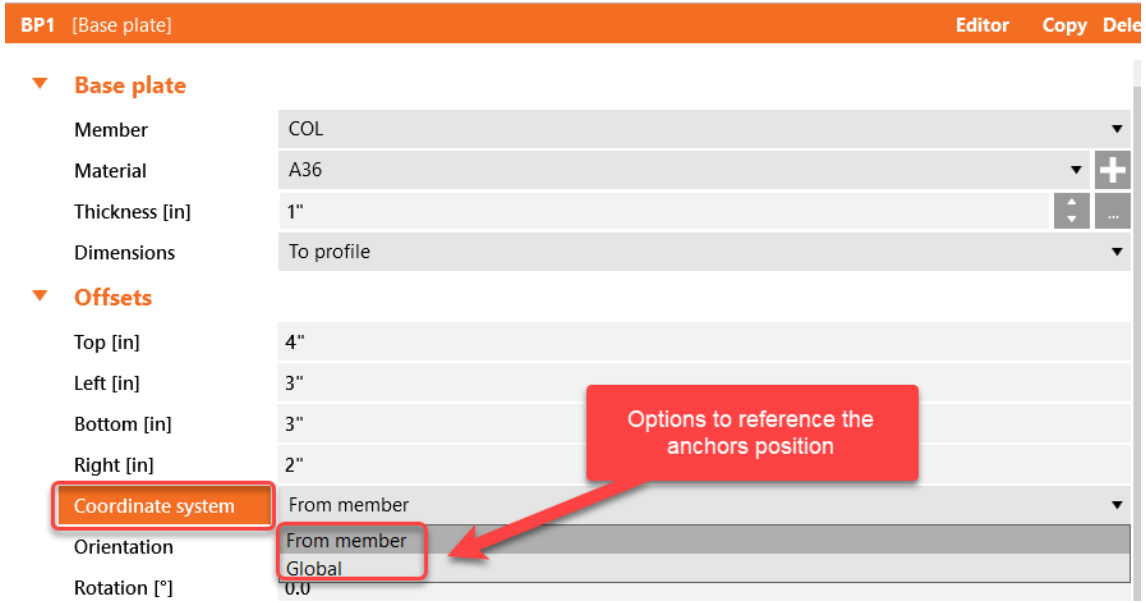
1. Base plate and anchors position and reference





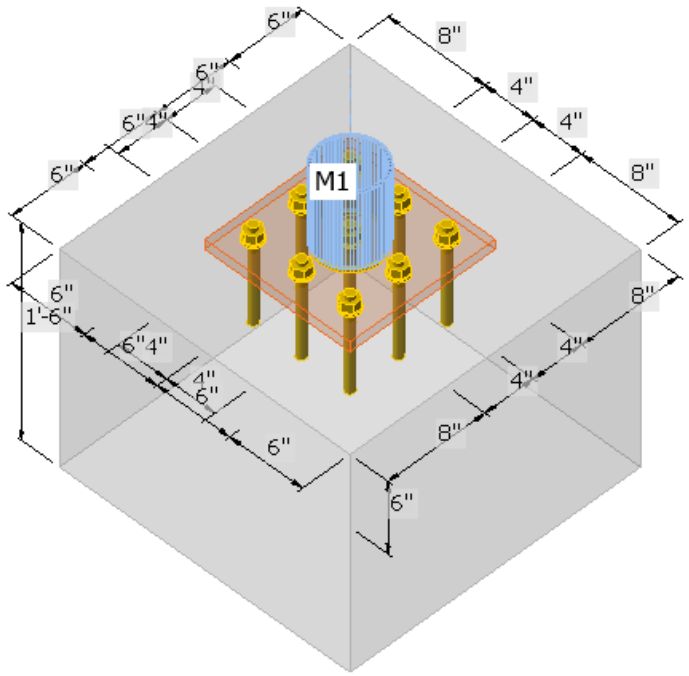


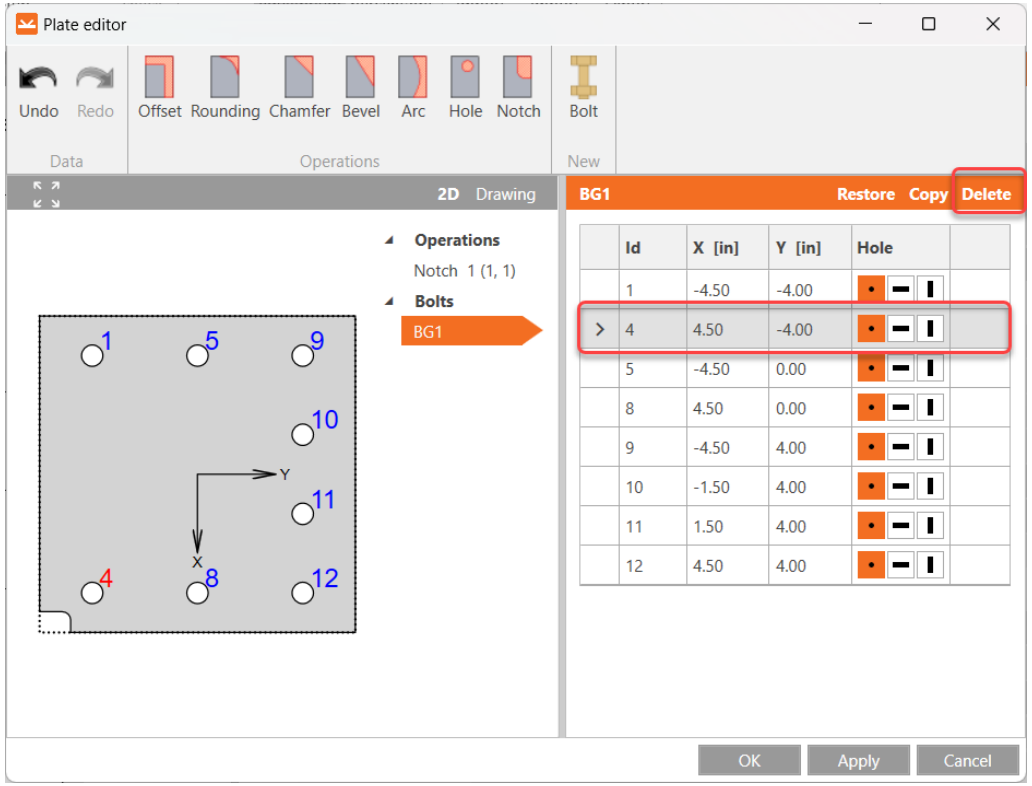




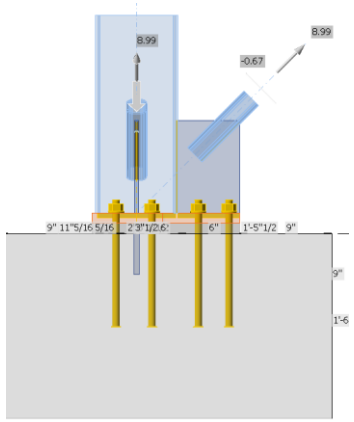
2. Base plate editor

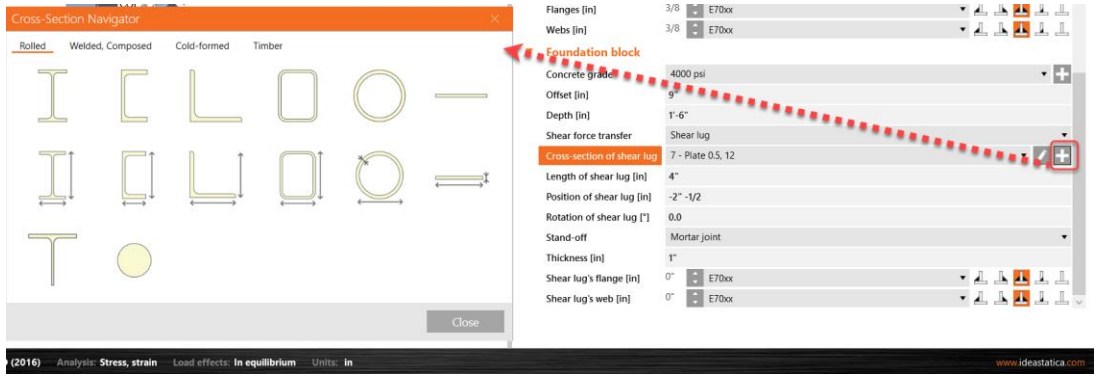
- Delete anchors
- Modify base plate shape





3. Shear lug options and design





- Select the shear lug shape from profile data base
- Change position and rotation of the shear lug
- Shear lug can be combined with mortar joint or direct stand options

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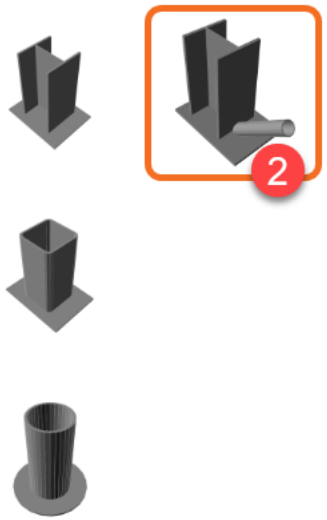
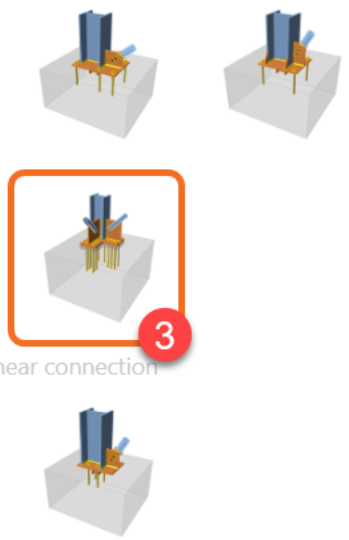
1. Class

2. Geometry



3. Design

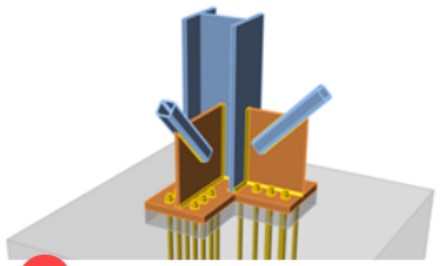
Moment connection



Shear connection

4. Parameters

Name	
Description	
Steel grade	A36
Bolt assembly	5/8 A325
Weld grade	E70xx
Concrete grade	4000 psi
Design code	
Design code edition	AISC 360-16 (LRFD)



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News

28.06.2023
Webinar: Design of Steel to Concrete Connections inc...
Steel base plate connections to concrete foundations or other concrete elements are critical to successfully transferring forces from the main structure to the ground. IDEA StatiCa helps you to model and design them. Join this webinar to learn all about steel to concrete joints.

20.06.2023
Breaking Barriers: Even Better Compliance with ACI c...
We've always claimed that IDEA Statica Detail is general enough that it can be used globally. Sure it is. But let's admit it, the environment for users working with ACI codes could be perceived as being a little hostile and confusing. Those days are over now. IDEA Statica Detail is now ready for fast and easy use of ACI codes and imperial units!

07.06.2023
Connection Wednesdays - Stiffness classification
Connection stiffness is a crucial aspect of a structure's design because, ultimately, the behavior of connected members should align with the assumptions initially made by the structure designer. This is especially true in the case of semi-rigid connections.

Shear lug design

When shear lugs are used, Appendix B of ACI 349-01 permits use of confinement in combination with bearing for transferring shear from shear lugs into the concrete. The commentary to ACI 349-01 suggests this mechanism is developed as follows:

1. Shear is initially transferred through the anchor rods to the grout or concrete by bearing augmented by shear resistance from confinement effects associated with tension anchors and external concurrent axial load.

2. Shear then progresses into a shear-friction mode.

The recommended bearing limit ϕP_{ubrg} per Section B.4.5.2 of ACI 349-01, Appendix B, is $\phi 1.3 f_c' A_1$. Using a ϕ consistent with ASCE 7 load factors (ϕ = 0.60), $\phi P_{ubrg} \approx 0.80 f_c' A_1$ and A_1 = embedded area of the shear lug (this does not include the portion of the lug in contact with the grout above the pier).

For bearing against an embedded base plate or column section where the bearing area is adjacent to the concrete surface, ACI 318-02 recommends that $\phi P_{ubrg} = 0.55 f_c' A_{brg}$, and A_{brg} = contact area between the base plate and/or column against the concrete, in^2.

Design Guide 1 -AISC

Bearing capacity check (ACI 349-01 – B.4.5, ACI 349-01 – B.11)

$\phi_c P_{br} = \phi \cdot 1.3 \cdot f_c' \cdot A_1 + \phi \cdot K_c \cdot (N_y - P_a) =$ 424.43 kip ≥ $V =$ 12.19 kip

Where:

$\phi = 0.7$ – resistance factor for bearing of bolts on steel

$f_c' = 4.0$ ksi – concrete compressive strength

$A_1 = 42.1911$ in^2 – projected area of the embedded area of the shear lug in the direction of the force excluding the portion of the lug in contact with the grout above concrete member

$K_c = 1.60$ – confinement coefficient

$N_y = 96.19$ kip – yield strength of tensioned anchors

- $N_y = n \cdot A_{se} \cdot F_y$, where:
  - $n =$ 8.0 – number of tensioned anchors
  - $A_{se} =$ 0.3340 in^2 – tensile stress area of an anchor
  - $F_y =$ 36.0 ksi – anchor yield strength

$P_a =$ -145.64 kip – external axial load

Concrete breakout strength check (ACI 349 – B11)

$\phi V_{cb} = \phi \cdot \Psi_{\alpha,v} \cdot A_{vc} \cdot 4.0 \cdot \sqrt{f_c'} =$ 131.70 kip ≥ $V =$ 12.19 kip

Where:

$\phi = 0.85$ – steel embedment material resistance factor for reinforcement

$\Psi_{\alpha,V} = 1.12$ – modification factor for shear lug loaded at an angle with the concrete edge

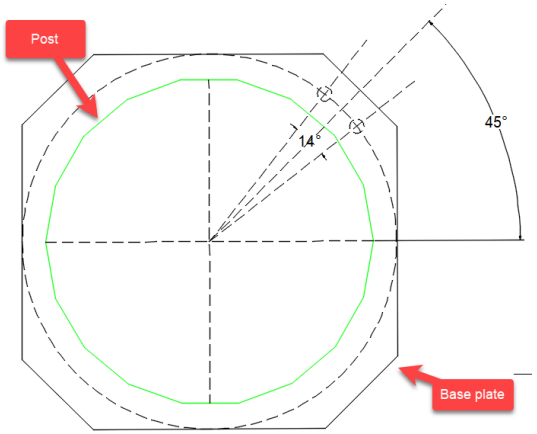
- $\Psi_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + (0.5 \cdot \sin \alpha_V)^2}}$, where:
  - $\alpha_V =$ 30.9 ° – angle between direction of shear force and direction perpendicular to concrete edge

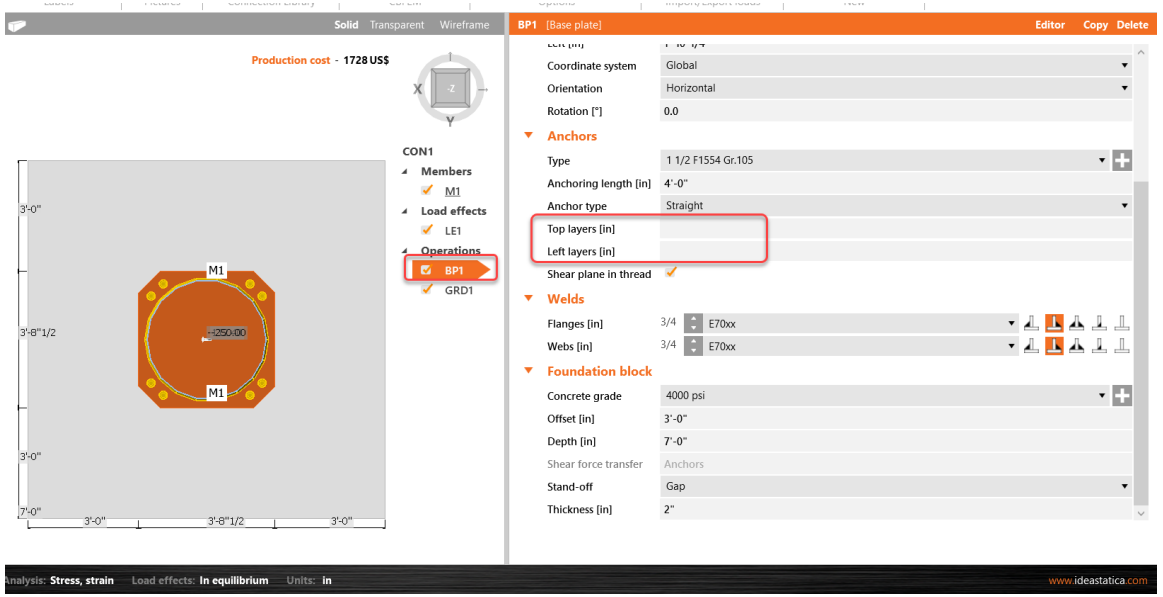
$A_{vc} = 548.6929$ in^2 – effective stress area defined by projecting a 45° plane from the bearing edges of the shear lug to the free surface in the direction of the shear load. The bearing area of the shear lug is excluded from the projected area.

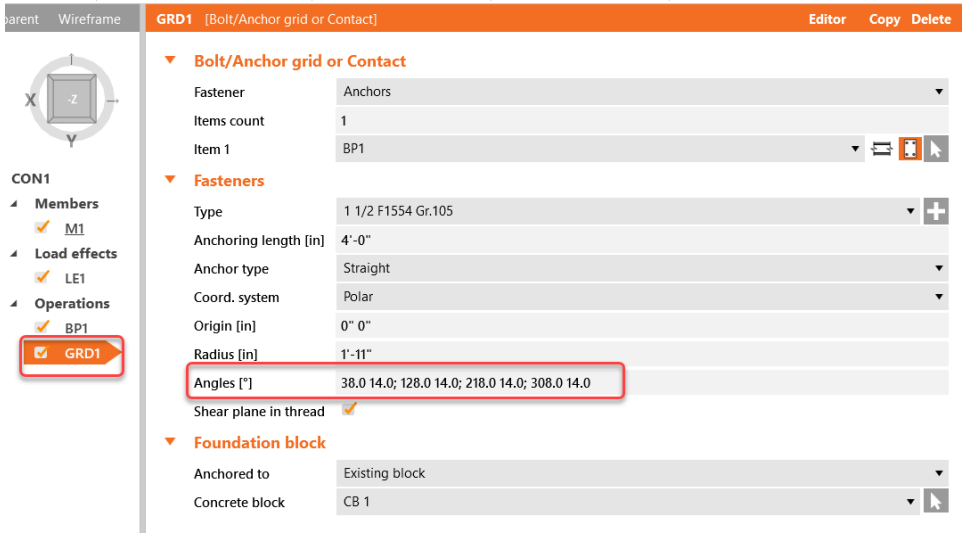
$f_c' = 4.0$ ksi – concrete compressive strength

4. Base plate and grid operation

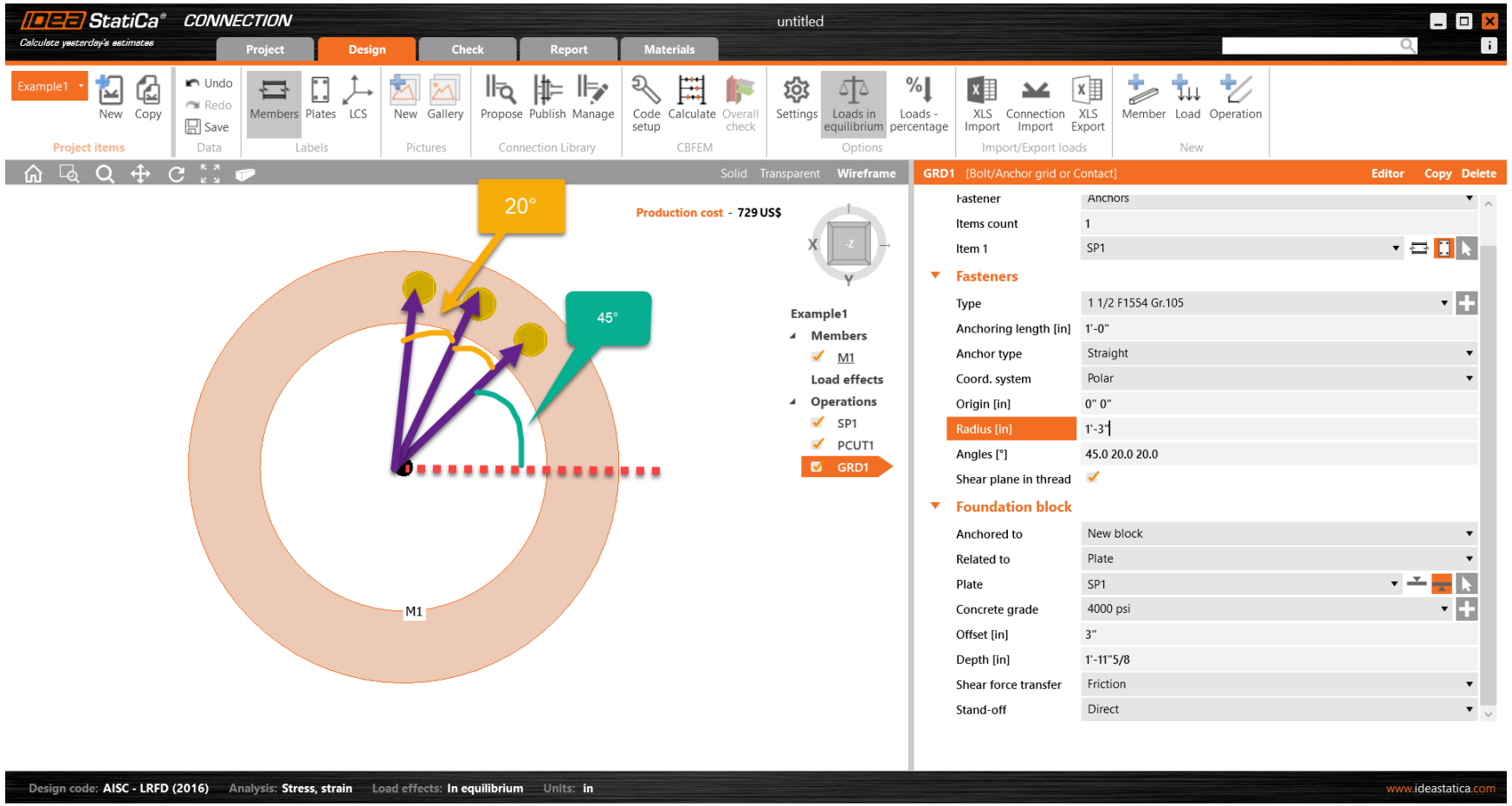
- Use base plate operation, delete anchors and use a grid operation



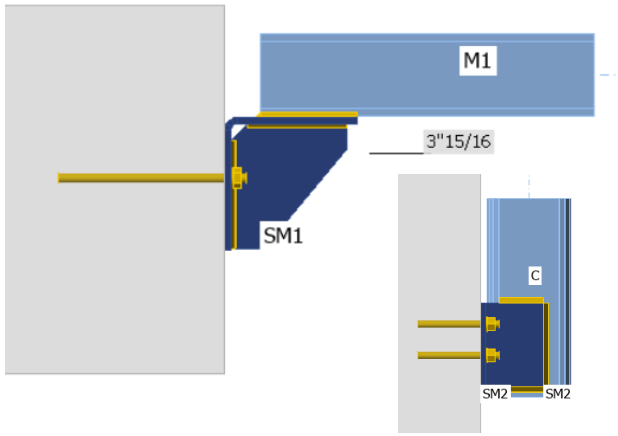




Polar position of anchors



5. Lateral wall anchorage

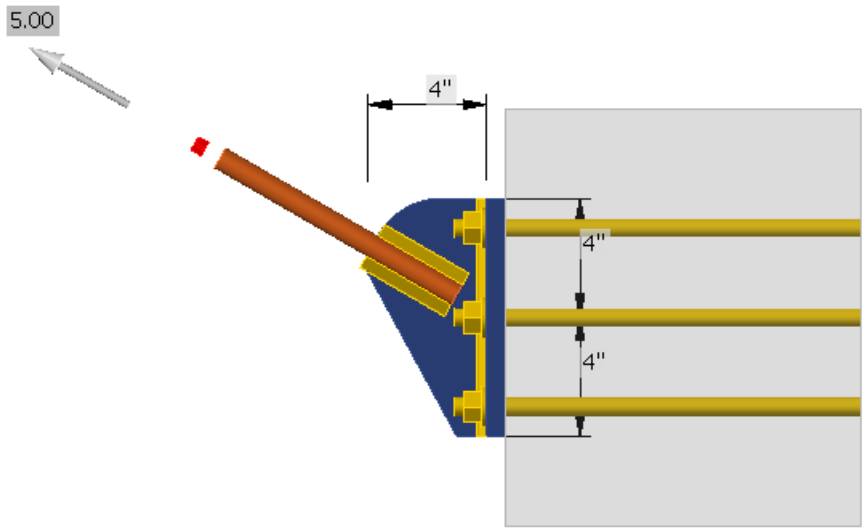


- Grid operation can be attached to a stiffening member
- You can create different grid operations in one model attached to the same concrete block
- However, a warning will be displayed:

Anchor groups at separate base plates interact with each other in one concrete block. This is out of the scope of standards for anchorage design. Concrete breakout in tension and concrete pryout are not checked.

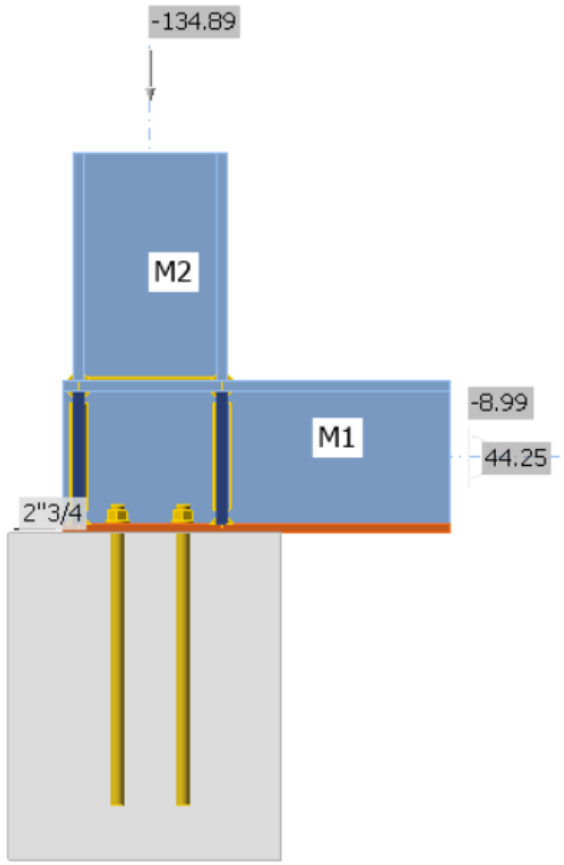
(CEB-FIB: Bulletin 58 - Design of anchorages in concrete (2011) – Chapter 1.2: Figure 1.2-8 and Figure 1.2-9)

6. Steel cable anchorage

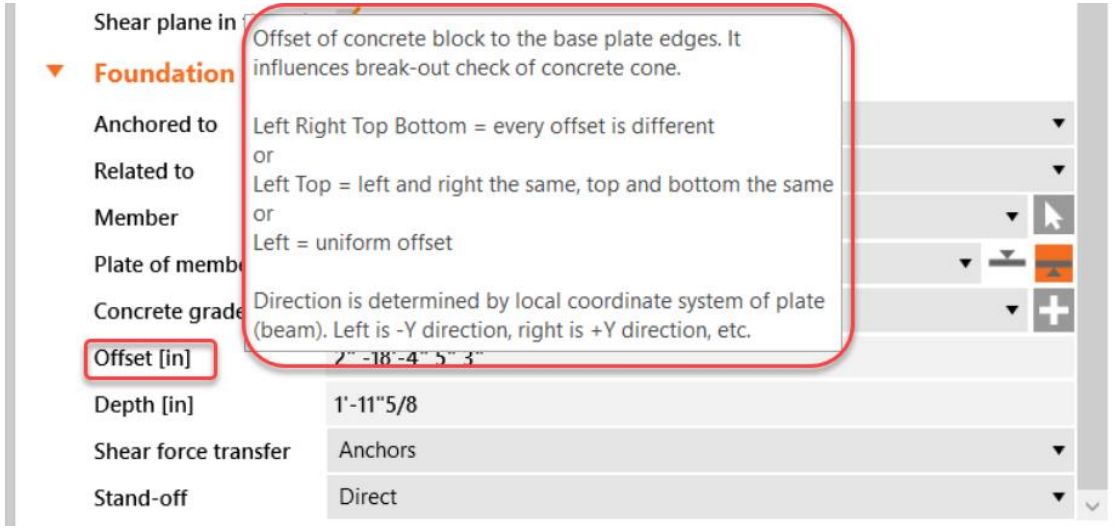


- Grid anchor operation using a plate
- Rod member can be used only with:
  Gusset plate or connecting plate

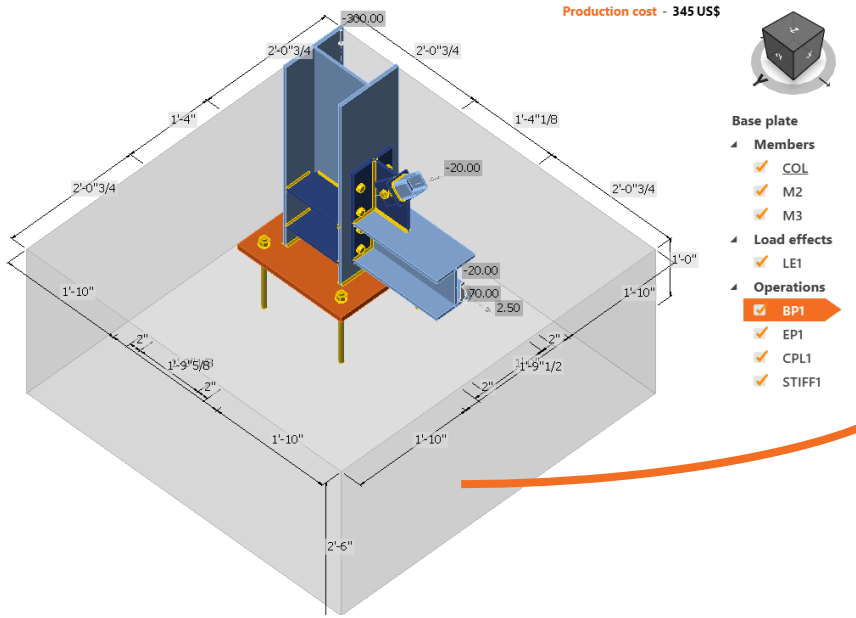
7. Partially supported base plate



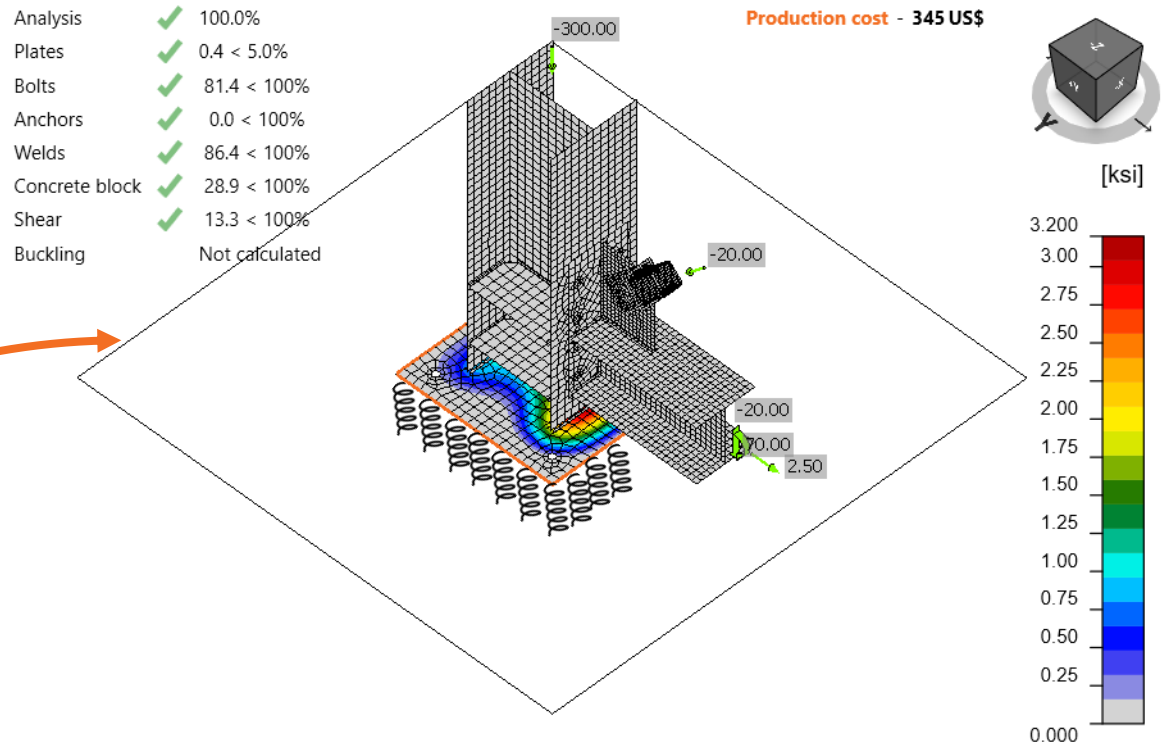
- Anchor attached to a member's plate
- Concrete block dimension



Behind the scenes - Concrete block

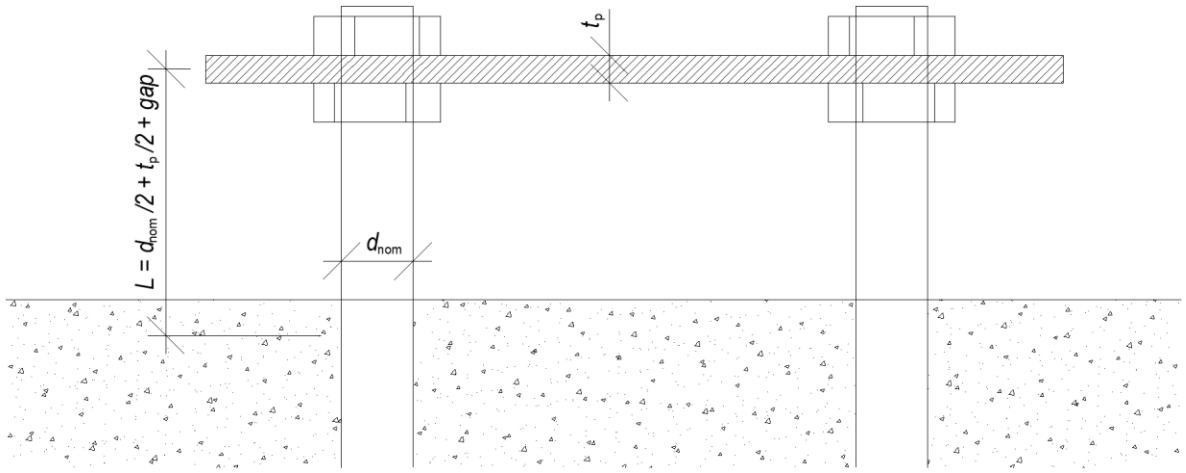


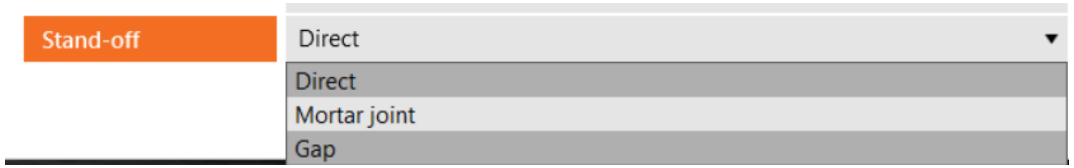
Concrete block *is represented* as a 3D Element in the model view.



However, in the CBFEM analysis, the concrete block is modeled as a **shell element**

Tension force by anchors

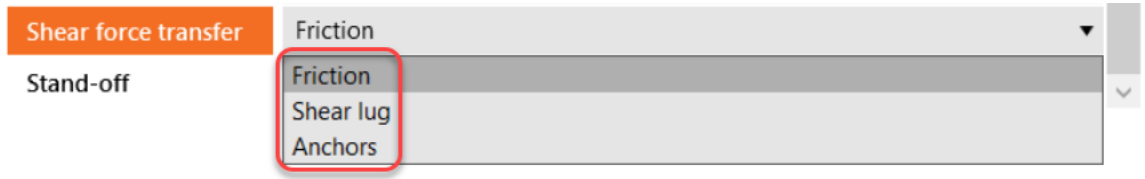


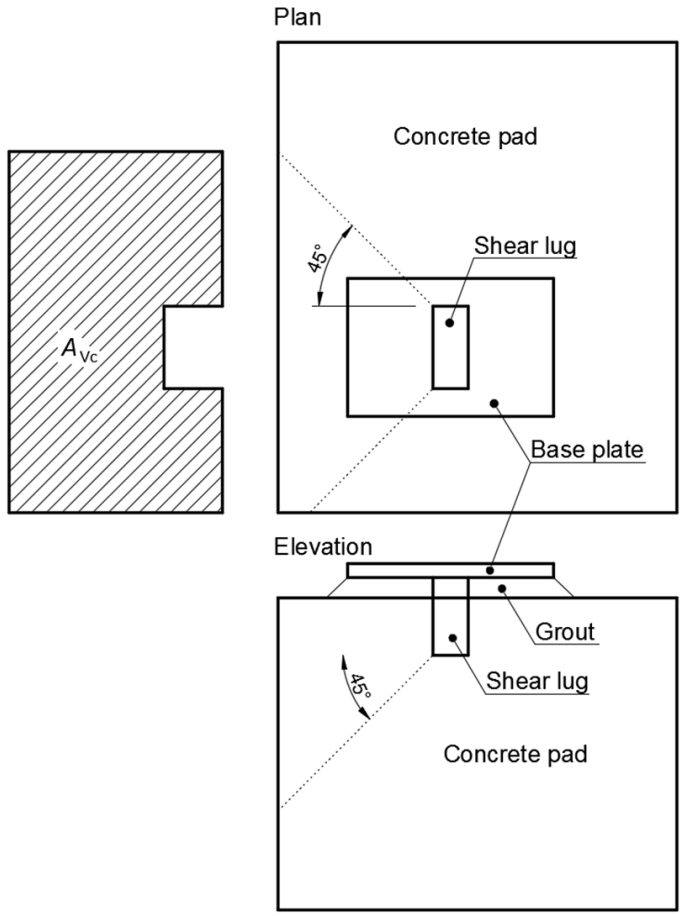


- Anchors are modeled as springs
- If a **gap** is selected, that portion is analyzed as a beam element
- **Gap** - Shear is transfer through anchors
- **Mortar -**Steel strength in shear Vsa is multiplied by 0.8 (ACI 318-14 – 17.5.1.3).

Shear force

- Shear force is calculated as resultant of all the applied loads
- Shear force can be transfer by:
  - Friction
  - Shear lug
  - Anchors





Articles data base

Analysis

- Anchor bolts
- Anchors stand-off (gap)
- Concrete block

Design

- Code check of anchors according AISC and ACI
- Code check of concrete block according to AISC

Code check of anchors AISC - ACI

- Anchor rods are designed according to **AISC 360-16 – J9 and ACI 318-14 – Chapter 17**.
- The following resistances of anchor bolts are evaluated:

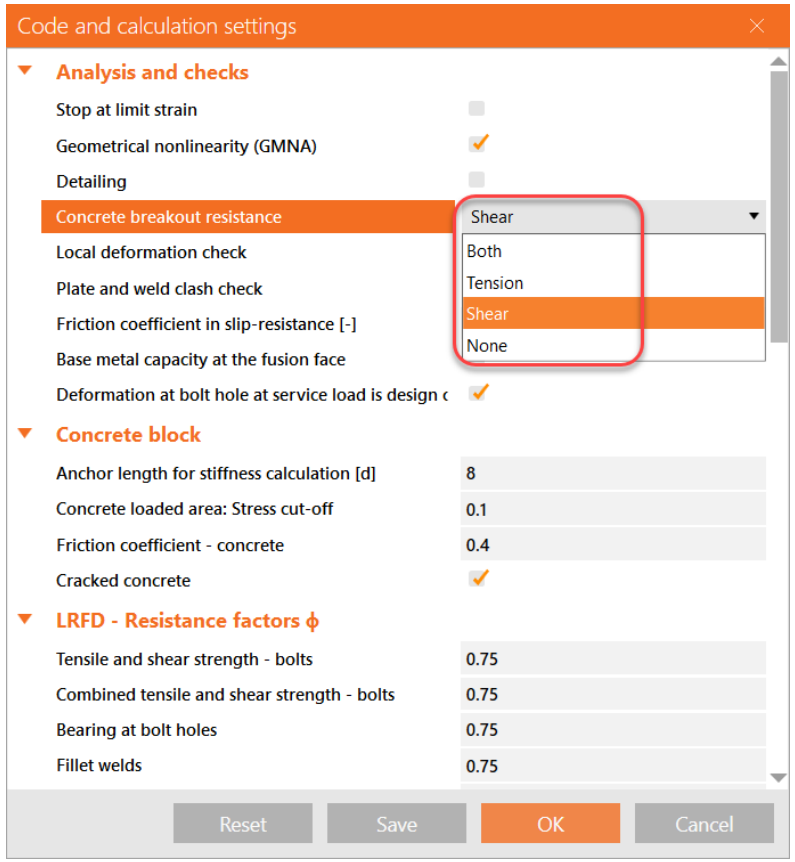
- Steel strength of anchor in tension ϕN_{sa},
- Concrete breakout strength in tension ϕN_{cbg},
- Concrete pullout strength ϕN_{p},
- Concrete side-face blowout strength ϕN_{sb},
- Steel strength of anchor in shear ϕV_{sa},
- Concrete breakout strength in shear ϕV_{cbg},
- Concrete pryout strength of anchor in shear ϕV_{cp}.

Code check of Concrete blocks ACI

- Concrete in compression: Bearing strength in compression is designed according to AISC 360-16, Section J8.

$$f_{p(max)} = 0.85 f_c \sqrt{\frac{A_2}{A_1}} \leq 1.7 f'_c$$

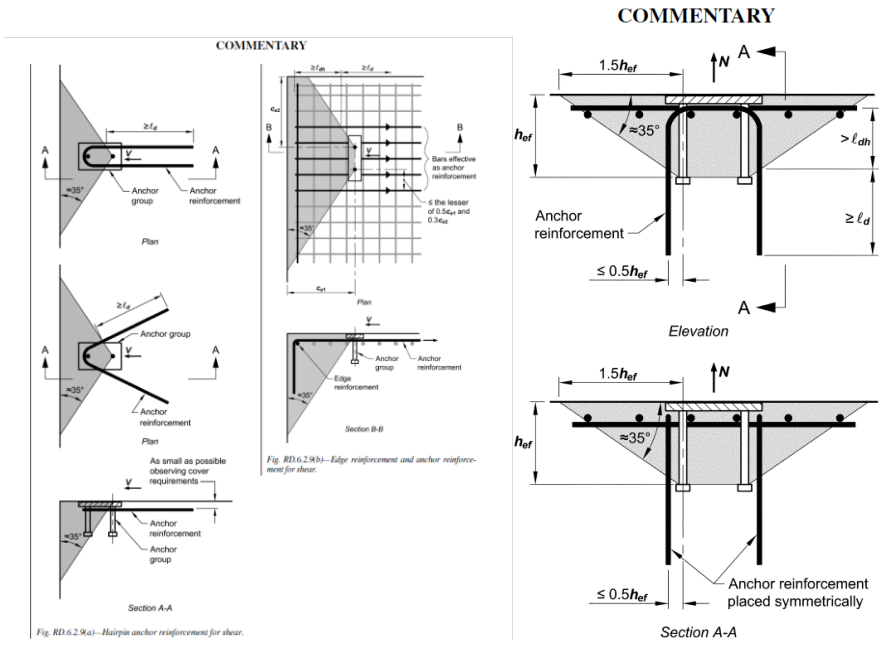
Option to overpass the concrete breakout resistance as the user is adding supplementary reinforcement to the concrete block :



Supplementary reinforcement (ACI 318-14 – 17.4.2.9; ACI 318-14 – 17.5.2.9)

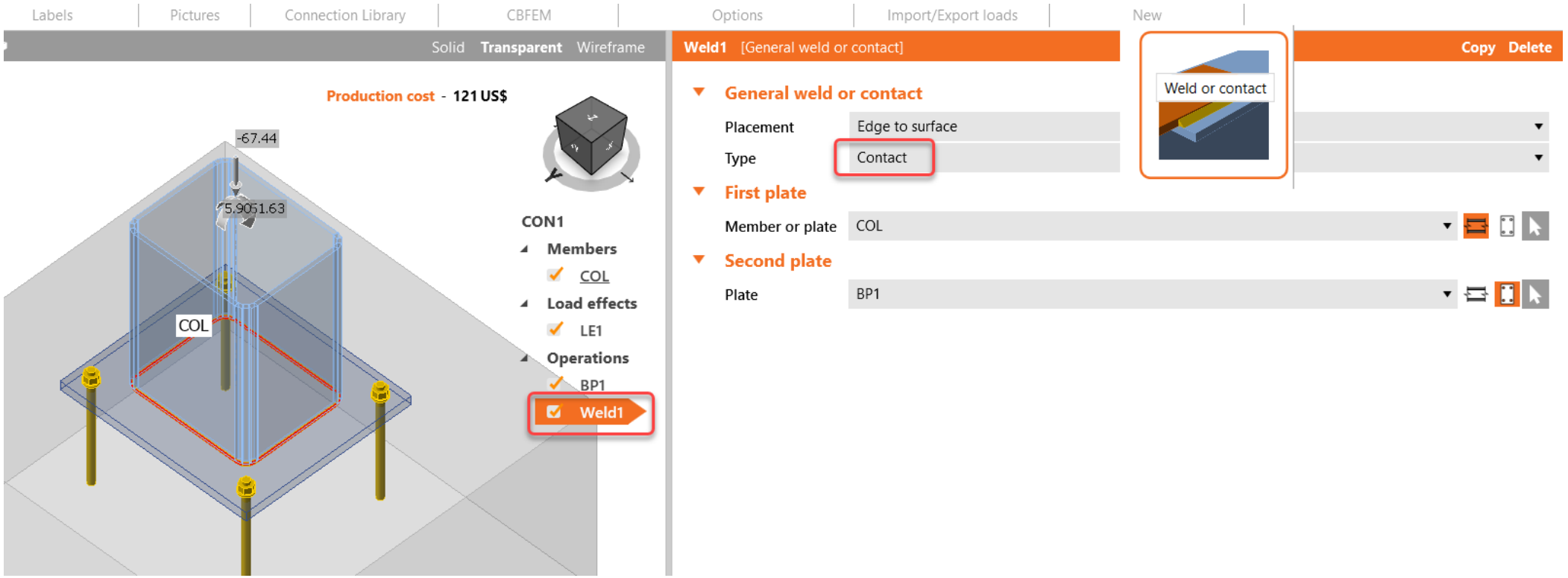
Supplementary reinforcement should resist force of 36.25 kip in tension and 5.06 kip in shear.

Supplementary reinforcement by ACI



Contact and weld

- User question: *If I enforce milling of the column end, is there any option in IdeaStatica to account for this, so that the weld size between the end cap and the column can be reduced?*



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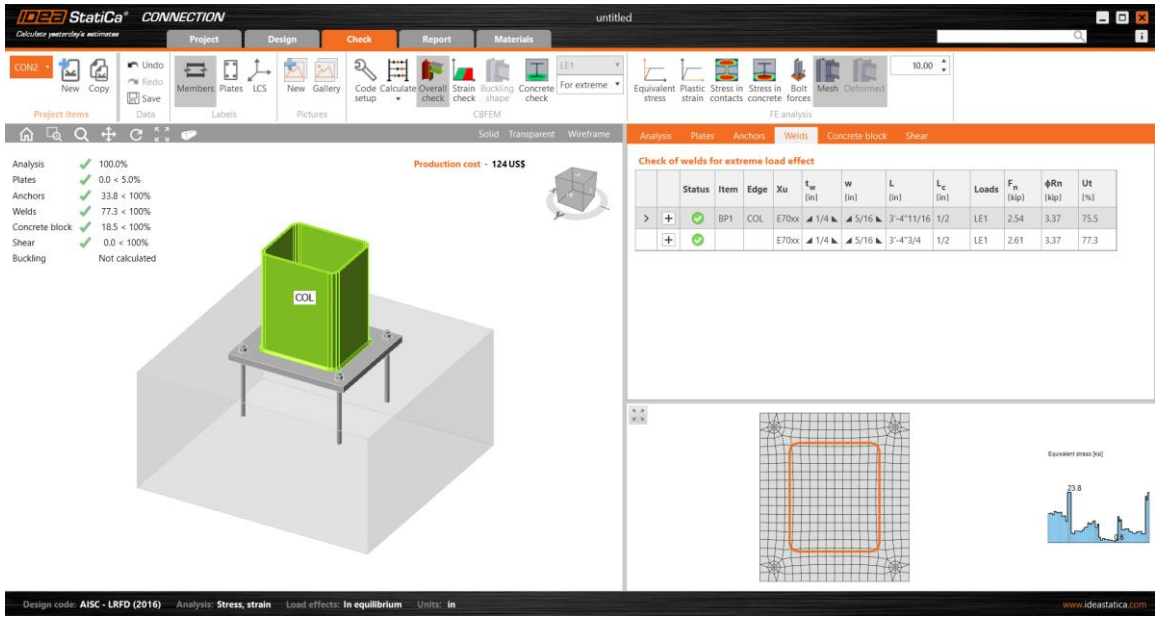
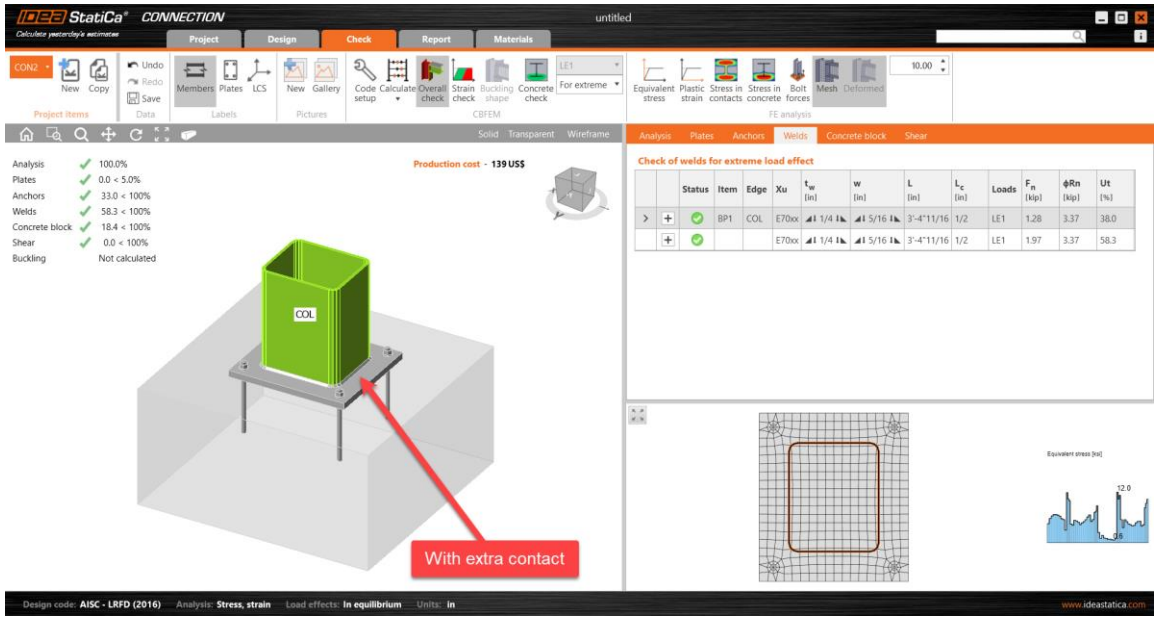
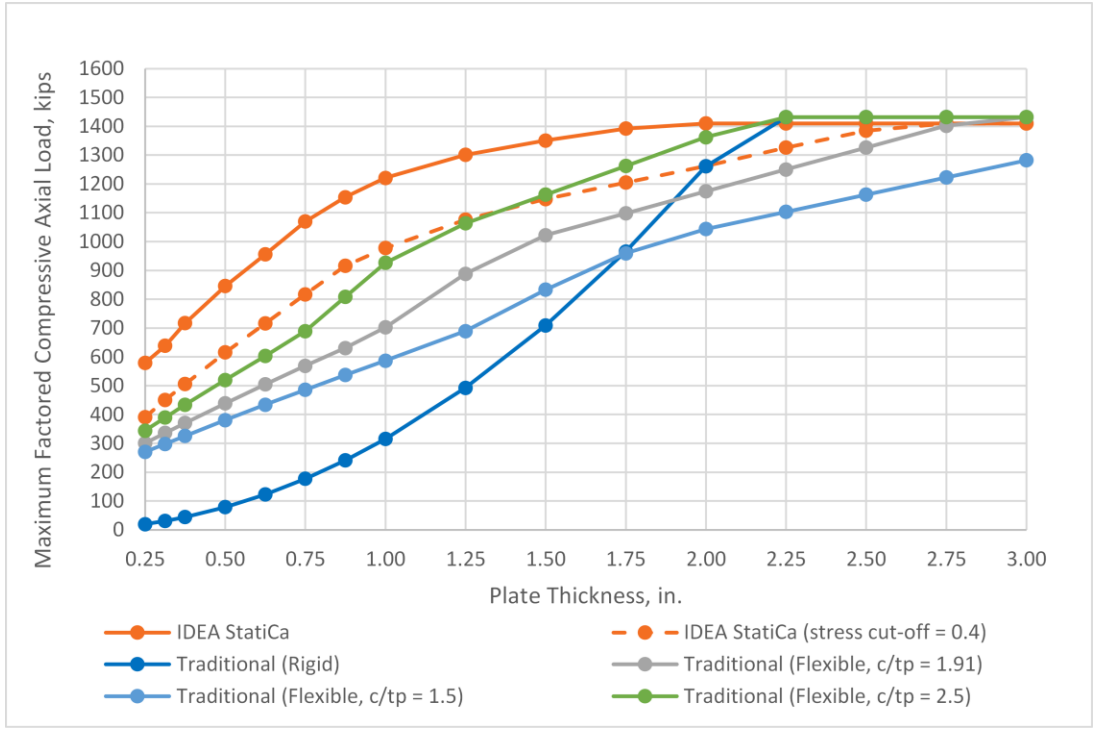
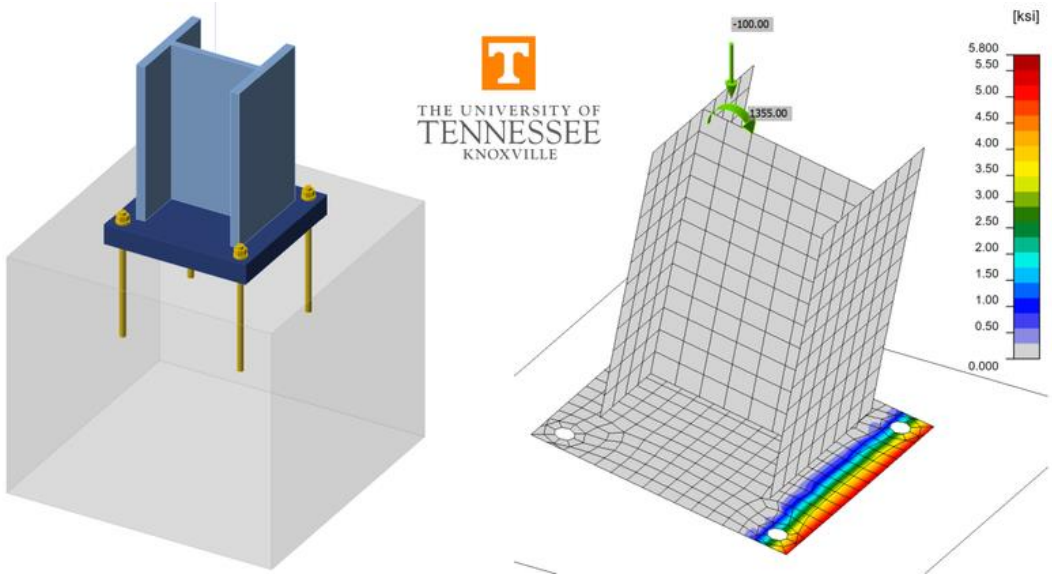




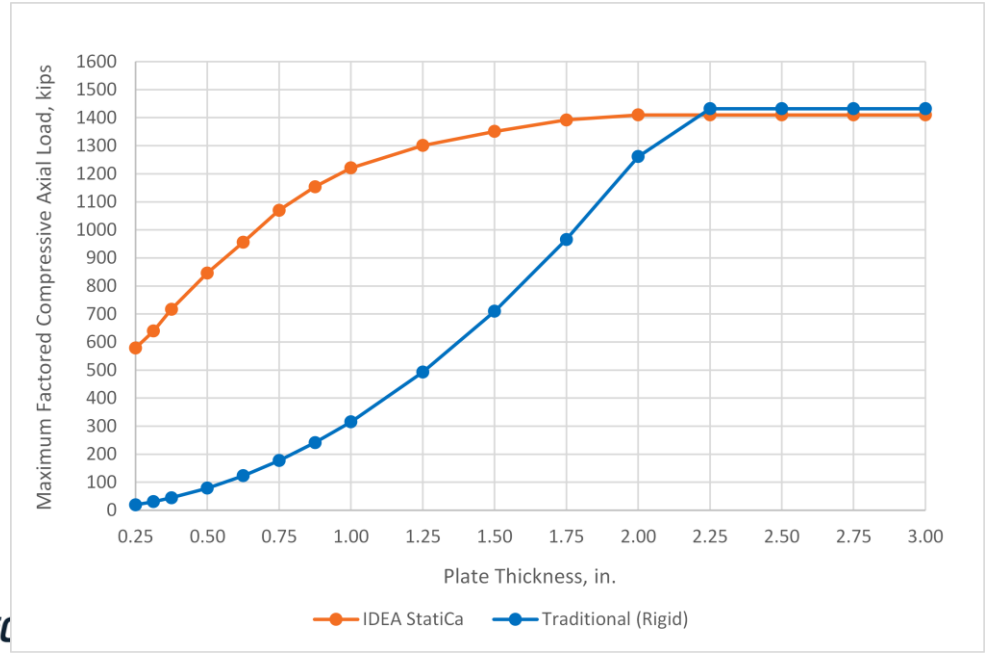
Verification study: Base Plate Connections (AISC)

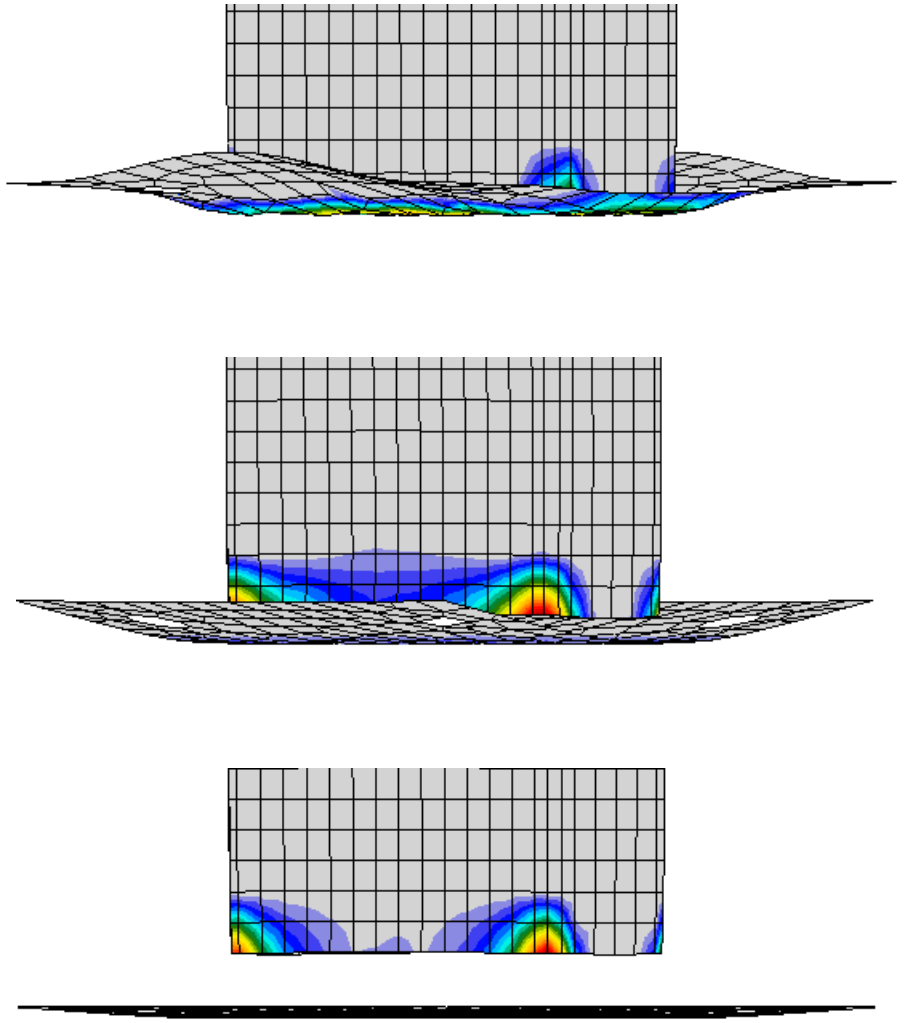




Key findings

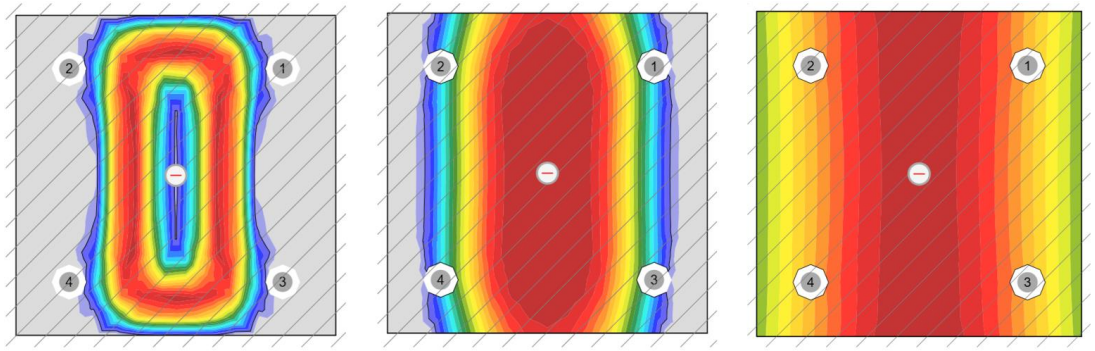
- For thick base plates that better conform to the rigid base plate assumption, IDEA StatiCa provides strengths that are comparable to the traditional calculations presented in AISC Design Guide 1.





Key findings

- For thinner base plates, where flexural yielding of the base plate due to bearing stresses controls, IDEA StatiCa can provide significantly greater strengths than the traditional calculations since the distribution of bearing stresses is calculated explicitly and redistributes upon the initiation of yielding of the base plate.



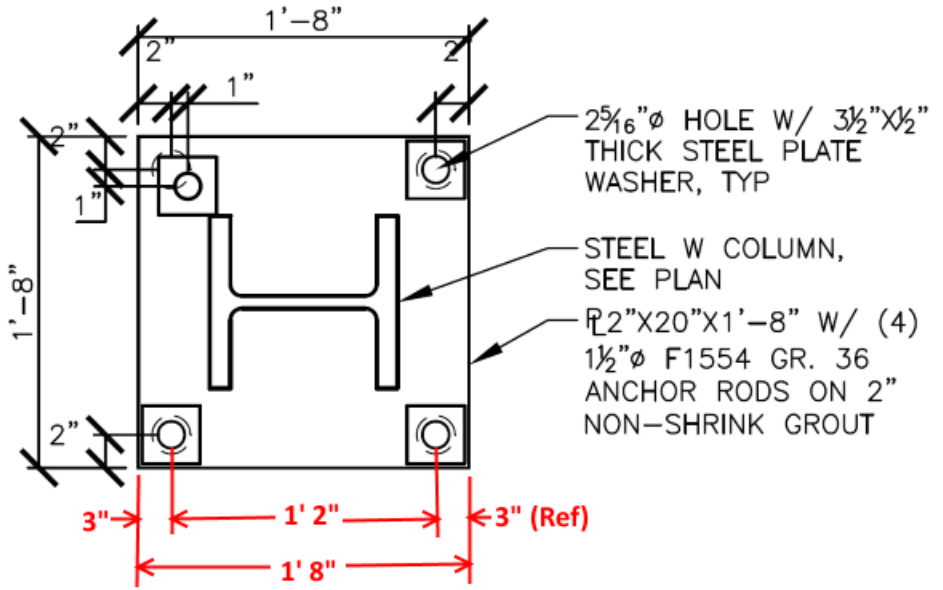
(a) t_p = 0.25 in. and P = 317 kips

(b) t_p = 0.75 in. and P = 458 kips

(c) t_p = 2.00 in. and P = 614 kips

Key findings

- IDEA StatiCa correctly calculates the shear strength of anchor rods but neglects the potential reductions in shear strength due to bending of the anchor rod within the base plate that can occur in certain base plate configurations (e.g., base plates with welded plate washers).



Limitations

- Plate washer welded to the base plate
- Changing resistance factors for specific anchors or code checks
- Welded bolts in the base plate - Embedded plates
- Hilti vs IDEA – Anchors in Profis have the real stiffness from their test, compared to the IDEA values.