

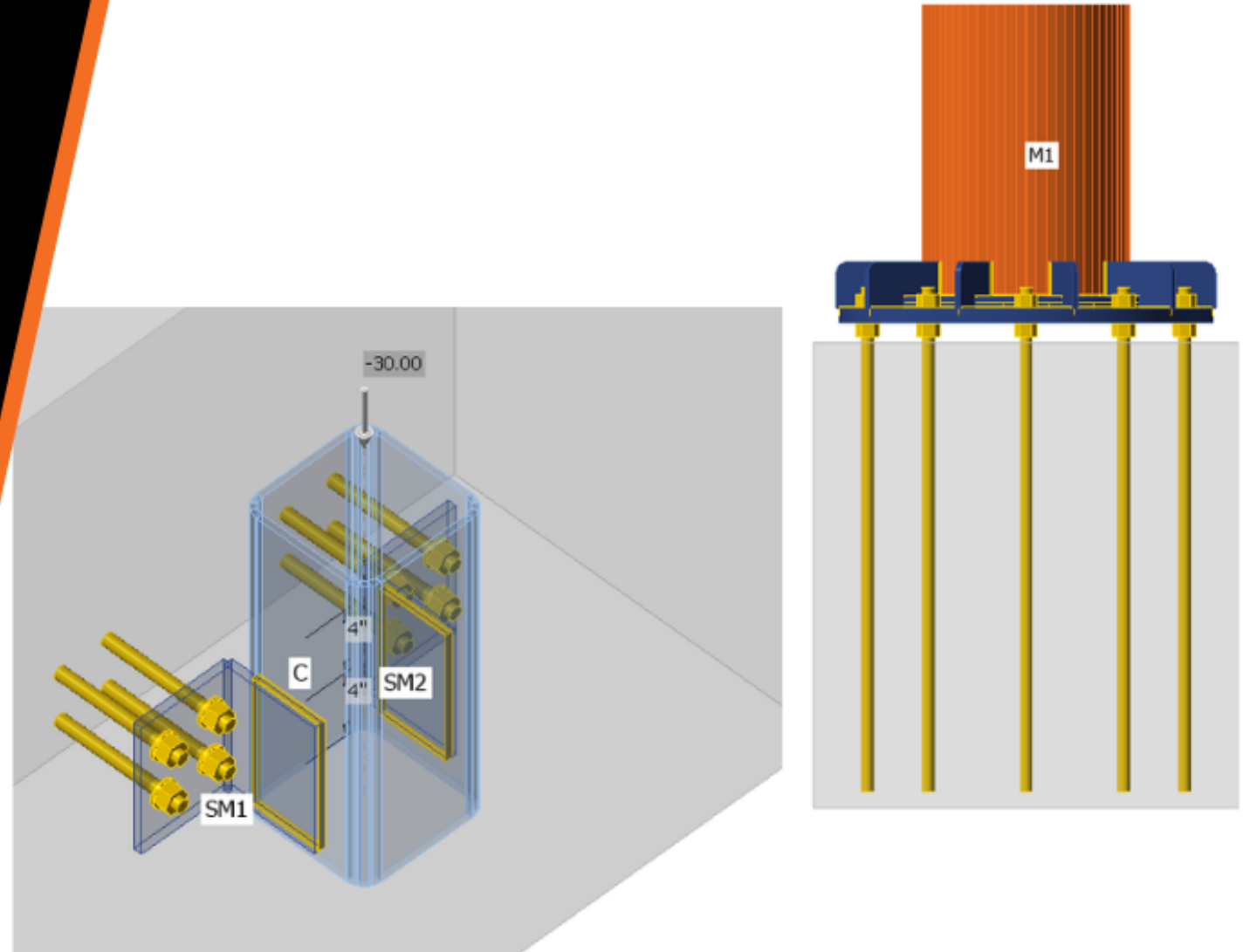
US Webinar

# Design of steel to concrete connections, including base plates

June 28  
12pm EST

**IDEA StatiCa**<sup>®</sup>

Calculate yesterday's estimates

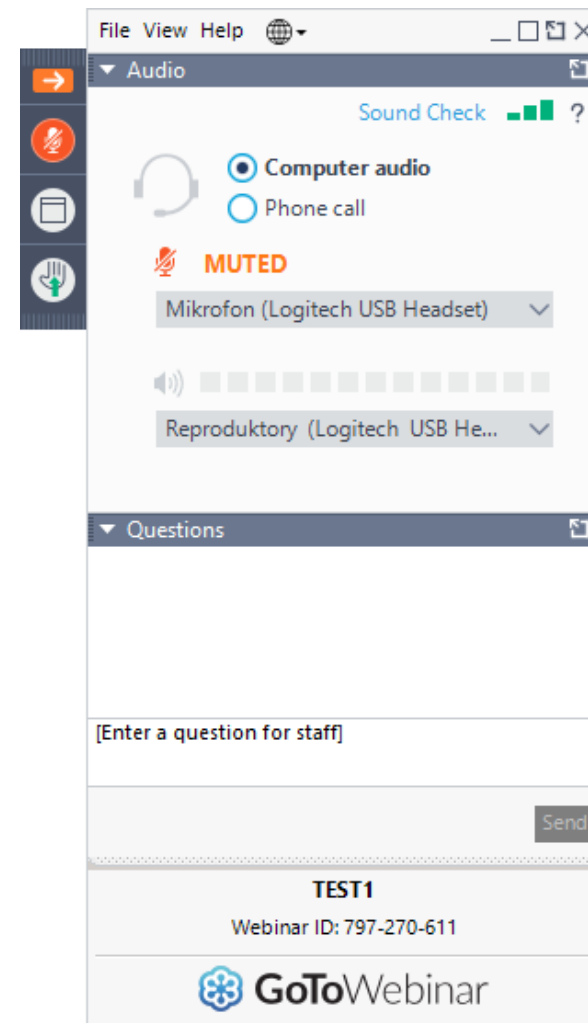


## Control Panel

When you first join a session, the Control Panel appears on the right side of your screen. Use the Control Panel to manage your session. To free up space on your desktop, you can collapse the Control Panel and use the Grab Tab to continue to manage your session.

- **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



The screenshot shows the GoToWebinar control panel interface. At the top, there is a menu with 'File', 'View', and 'Help'. Below this is a 'Sound Check' indicator with a green bar and a question mark. The 'Audio' section is expanded, showing options for 'Computer audio' (selected) and 'Phone call'. A microphone icon is labeled 'MUTED'. Below this, there are dropdown menus for 'Mikrofon (Logitech USB Headset)' and 'Reproduktory (Logitech USB He...'. A volume slider is visible. The 'Questions' section is also expanded, showing a text input field with the placeholder '[Enter a question for staff]' and a 'Send' button. At the bottom, the session name 'TEST1' and 'Webinar ID: 797-270-611' are displayed, along with the GoToWebinar logo.

# 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

**BP1 [Base plate]** Editor Copy Delete



**Base plate**

Member: M1  
Material: A36  
Thickness [in]: 13/16

**Dimensions**: Circle

**Offsets**

- To profile: To profile symmetrical
- Radius [in]: Rectangle
- Inner radius [in]: Rectangle symmetrical
- Circle
- Coordinate system: From member
- Orientation: Horizontal
- Rotation [°]: 0.0

**Anchors**

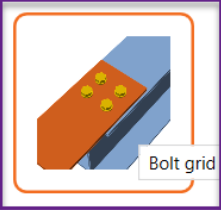
- Type: 5/8 A325
- Anchoring length [in]: 6"
- Anchor type: Straight
- Radius [in]: 6"
- Number: 0
- Shear plane in thread:

**Welds**

- Flanges [in]: 3/4 E70xx

# Anchor grid operation

**GRD1 [Bolt/Anchor grid or Contact]** Editor Copy Delete



**Bolt/Anchor grid or Contact**

Fastener: Anchors  
Items count: 1  
Item 1: SP3

**Fasteners**

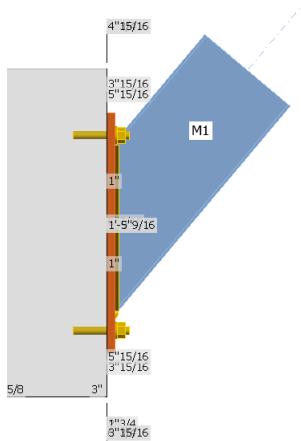
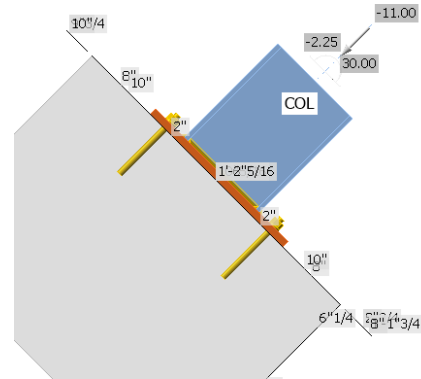
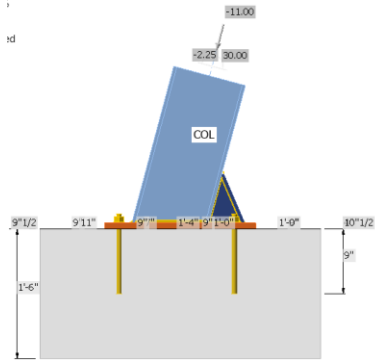
- Type: 1 1/2 F1554 Gr.105
- Anchoring length [in]: 6'-0"
- Anchor type: Straight
- Coord. system: Polar
- Origin [in]: 0" 0"
- Radius [in]: 1'-10"
- Angles [°]: 37.0 17.0; -37.0 -17.0; 127.0 17.0; 217.0 17.0
- Shear plane in thread:

**Foundation block**

- Anchored to: New block
- Related to: Plate
- Plate: SP3
- Concrete grade: 4000 psi
- Offset [in]: 2'-0"
- Depth [in]: 7'-0"



# 1. Base plate and anchors position and reference



<b>Orientation</b>	Horizontal
Rotation [°]	Perpendicular
<b>▼ Anchors</b>	Horizontal
	Vertical

BP1 [Base plate] Editor Copy Delete

- Base plate**
  - Member: COL
  - Material: A36
  - Thickness [in]: 1"
  - Dimensions**: To profile
  - Offsets**
    - To profile
    - To profile symmetrical
    - Rectangle
    - Rectangle symmetrical
    - Circle

Plate shape and reference to size it

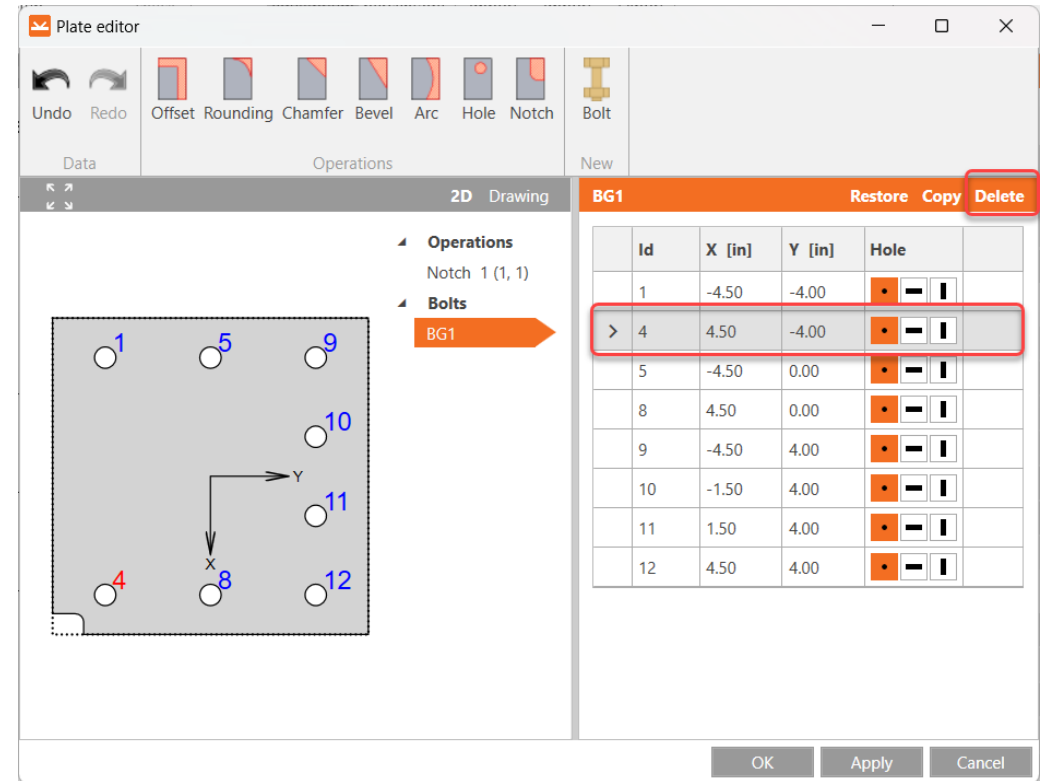
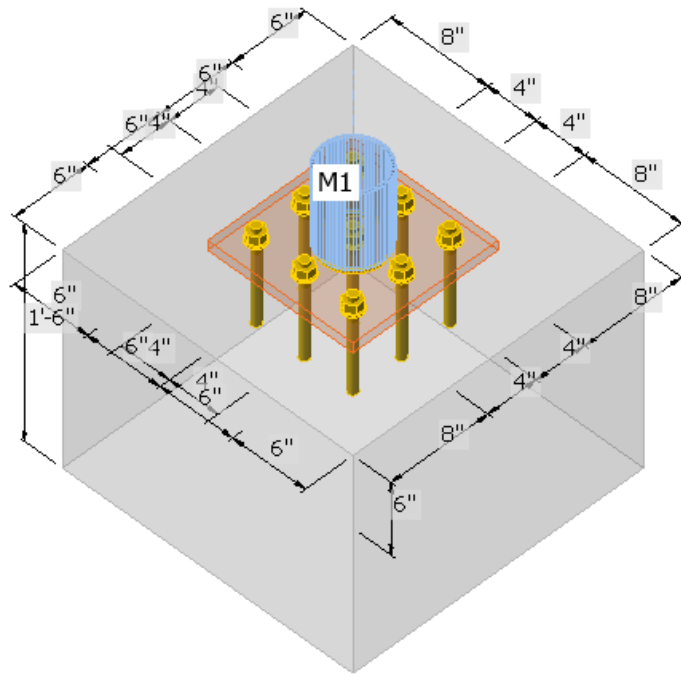
BP1 [Base plate] Editor Copy Delete

- Base plate**
  - Member: COL
  - Material: A36
  - Thickness [in]: 1"
  - Dimensions: To profile
- Offsets**
  - Top [in]: 4"
  - Left [in]: 3"
  - Bottom [in]: 3"
  - Right [in]: 2"
- Coordinate system**: From member
- Orientation: From member
- Rotation [°]: 0.0

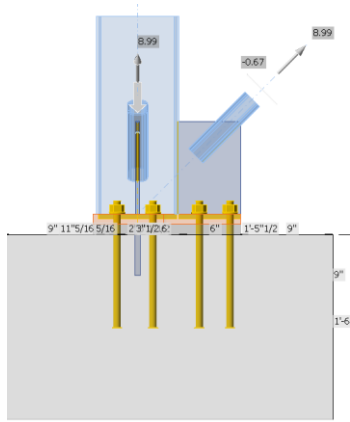
Options to reference the anchors position

## 2. Base plate editor

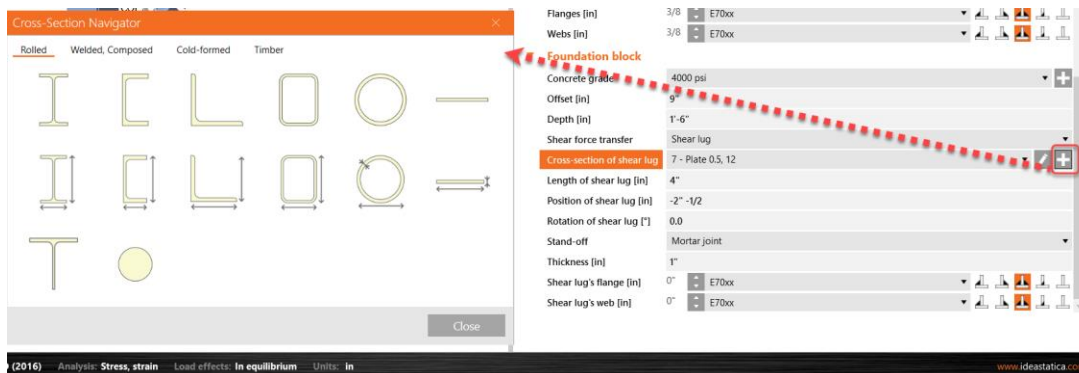
- Delete anchors
- Modify base plate shape



# 3. Shear lug options and design



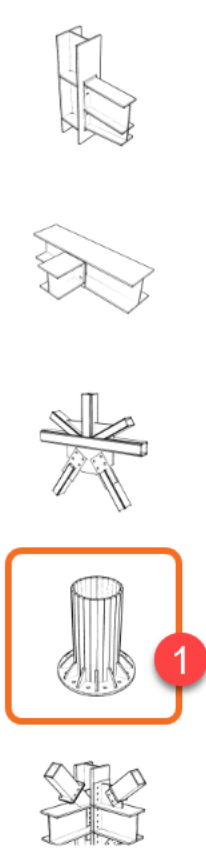
- Select the shear lug shape from profile data base
- Change position and rotation of the shear lug
- Shear lug can be combined with mortar joint or direct stand options



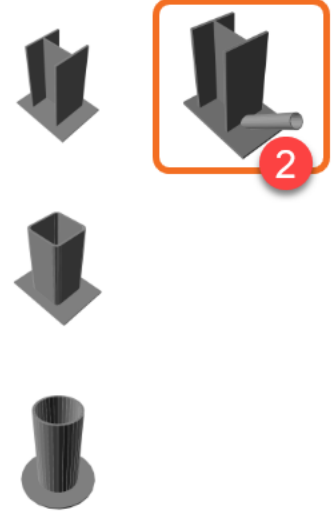


New project

1. Class

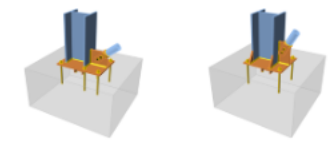


2. Geometry

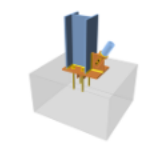


3. Design

Moment connection

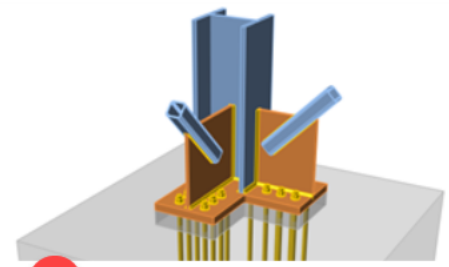


Shear connection



4. Parameters

Name	<input type="text"/>
Description	<input type="text"/>
Steel grade	A36 <input type="button" value="↺"/>
Bolt assembly	5/8 A325 <input type="button" value="↺"/>
Weld grade	E70xx <input type="button" value="↺"/>
Concrete grade	4000 psi <input type="button" value="↺"/>
Design code	▾
Design code edition	AISC 360-16 (LRFD) ▾



**4** Create project

# 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  $\phi P_{ubrg}$  per Section B.4.5.2 of ACI 349-01, Appendix B, is  $\phi 1.3f'_c A_1$ . Using a  $\phi$  consistent with ASCE 7 load factors ( $\phi = 0.60$ ),  $\phi P_{ubrg} \approx 0.80f'_c A_1$  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  $\phi P_{ubrg} = 0.55f'_c A_{brg}$ , and  $A_{brg}$  = contact area between the base plate and/or column against the concrete, in<sup>2</sup>.

Design Guide 1 -AISC

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

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

Where:

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

$f'_c = 4.0 \text{ ksi}$  – concrete compressive strength

$A_1 = 42.1911 \text{ in}^2$  – 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

$N_y = 96.19 \text{ kip}$  – yield strength of tensioned anchors

•  $N_y = n \cdot A_{se} \cdot F_y$ , where:

◦  $n = 8.0$  – number of tensioned anchors

◦  $A_{se} = 0.3340 \text{ in}^2$  – tensile stress area of an anchor

◦  $F_y = 36.0 \text{ ksi}$  – anchor yield strength

$P_a = -145.64 \text{ kip}$  – external axial load

## Concrete breakout strength check (ACI 349 – B11)

$$\phi V_{cb} = \phi \cdot \Psi_{\alpha,V} \cdot A_{vc} \cdot 4.0 \cdot \sqrt{f'_c} = 131.70 \text{ kip} \geq V = 12.19 \text{ kip}$$

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:

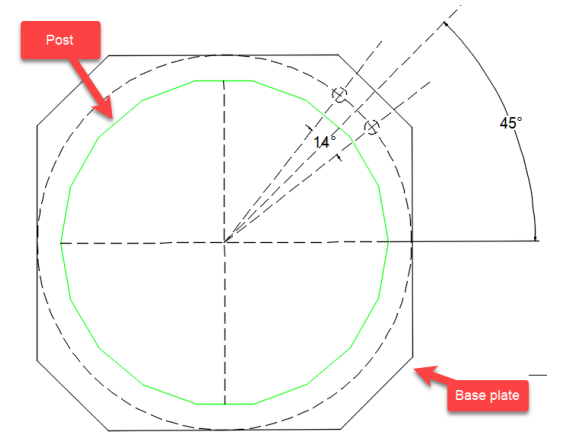
◦  $\alpha_V = 30.9^\circ$  – angle between direction of shear force and direction perpendicular to concrete edge

$A_{vc} = 548.6929 \text{ in}^2$  – 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.

$f'_c = 4.0 \text{ ksi}$  – concrete compressive strength

# 4. Base plate and grid operation

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



Software interface showing the BP1 (Base plate) operation settings. The left panel displays a 3D model of the base plate with dimensions: 3'-0" (width), 3'-8 1/2" (height), and 7'-0" (total width). The right panel shows the following settings:

Property	Value
Coordinate system	Global
Orientation	Horizontal
Rotation [°]	0.0
<b>Anchors</b>	
Type	1 1/2 F1554 Gr.105
Anchoring length [in]	4'-0"
Anchor type	Straight
Top layers [in]	
Left layers [in]	
Shear plane in thread	<input checked="" type="checkbox"/>
<b>Welds</b>	
Flanges [in]	3/4 E70xx
Webs [in]	3/4 E70xx
<b>Foundation block</b>	
Concrete grade	4000 psi
Offset [in]	3'-0"
Depth [in]	7'-0"
Shear force transfer	Anchors
Stand-off	Gap
Thickness [in]	2"

Software interface showing the GRD1 (Bolt/Anchor grid or Contact) operation settings. The left panel displays a 3D model of the base plate with dimensions: 3'-0" (width), 3'-8 1/2" (height), and 7'-0" (total width). The right panel shows the following settings:

Property	Value
<b>Bolt/Anchor grid or Contact</b>	
Fastener	Anchors
Items count	1
Item 1	BP1
<b>Fasteners</b>	
Type	1 1/2 F1554 Gr.105
Anchoring length [in]	4'-0"
Anchor type	Straight
Coord. system	Polar
Origin [in]	0" 0"
Radius [in]	1'-11"
Angles [°]	38.0 14.0; 128.0 14.0; 218.0 14.0; 308.0 14.0
Shear plane in thread	<input checked="" type="checkbox"/>
<b>Foundation block</b>	
Anchored to	Existing block
Concrete block	CB 1

# Polar position of anchors

The screenshot displays the IDEA StatiCa CONNECTION software interface. The main workspace shows a circular anchor grid with three anchors. The anchors are positioned at 20°, 45°, and 20° from a horizontal reference line. The software interface includes a toolbar with various tools, a central workspace, and a right-hand properties panel.

**Production cost - 729 US\$**

**Example1**

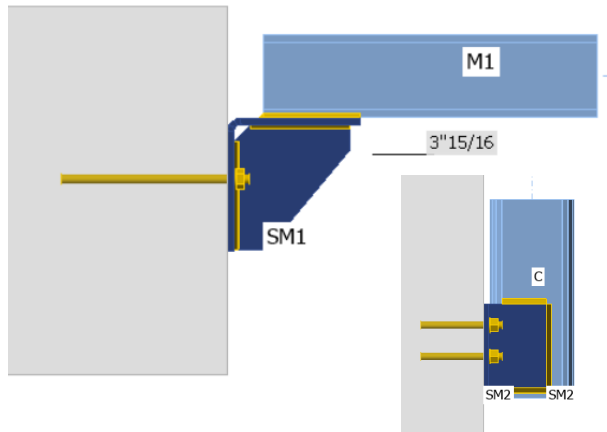
- Members
  - ✓ M1
- Load effects
  - ✓ SP1
  - ✓ PCUT1
- Operations
  - ✓ GRD1

**GRD1 [Bolt/Anchor grid or Contact]**

Fastener	Anchors
Items count	1
Item 1	SP1
<b>Fasteners</b>	
Type	1 1/2 F1554 Gr.105
Anchoring length [in]	1'-0"
Anchor type	Straight
Coord. system	Polar
Origin [in]	0'-0"
Radius [in]	1'-3"
Angles [°]	45.0 20.0 20.0
Shear plane in thread	✓
<b>Foundation block</b>	
Anchored to	New block
Related to	Plate
Plate	SP1
Concrete grade	4000 psi
Offset [in]	3"
Depth [in]	1'-11"5/8
Shear force transfer	Friction
Stand-off	Direct

Design code: AISC - LRFD (2016) Analysis: Stress, strain Load effects: In equilibrium Units: in [www.ideastatica.com](http://www.ideastatica.com)

# 5. Lateral wall anchorage

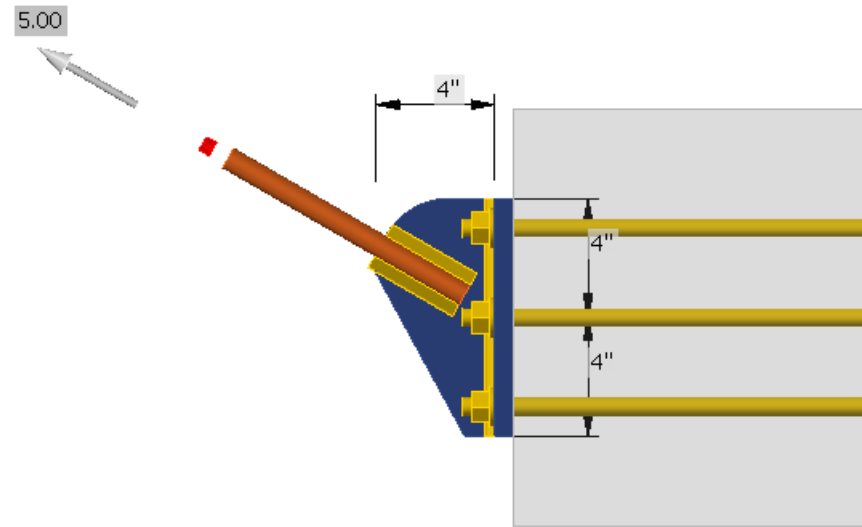


- Grid operation can be attached to a stiffening member
- You can create different grid operations in one model attached to the same concrete block
- However, a warning will be displayed:

*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.*

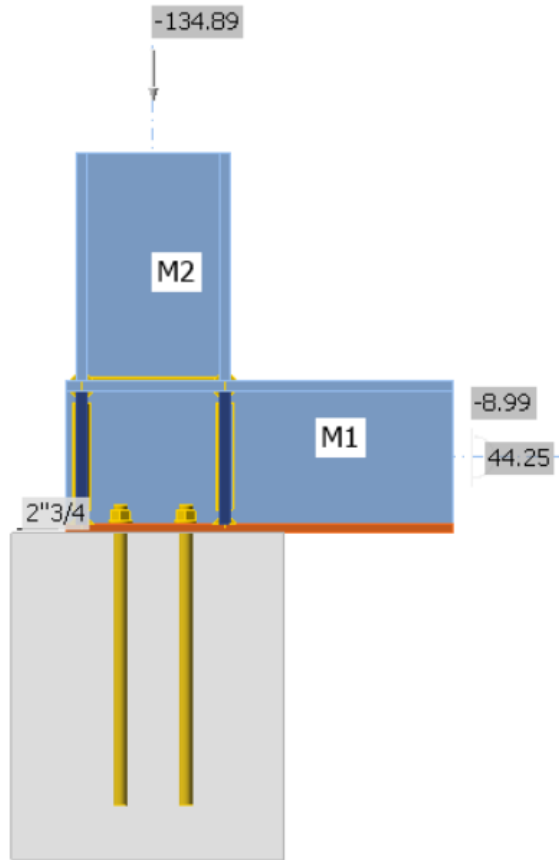
*(CEB-FIB: Bulletin 58 - Design of anchorages in concrete (2011) – Chapter 1.2: Figure 1.2-8 and Figure 1.2-9)*

## 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

Shear plane in

▼ **Foundation** Offset of concrete block to the base plate edges. It influences break-out check of concrete cone.

Anchored to Left Right Top Bottom = every offset is different

Related to Left Top = left and right the same, top and bottom the same

Member Left = uniform offset

Plate of member

Concrete grade Direction is determined by local coordinate system of plate (beam). Left is -Y direction, right is +Y direction, etc.

**Offset [in]** 2" -18" -4" 5" 3"

Depth [in] 1'-11" 5/8

Shear force transfer Anchors

Stand-off Direct

# Behind the scenes - Concrete block

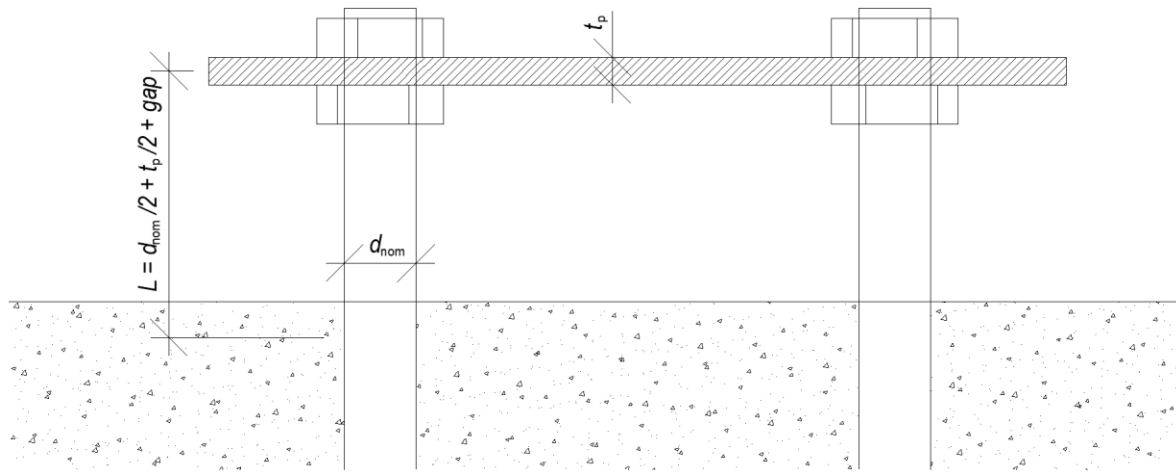


Concrete block *is represented* as a 3D Element in the model view.

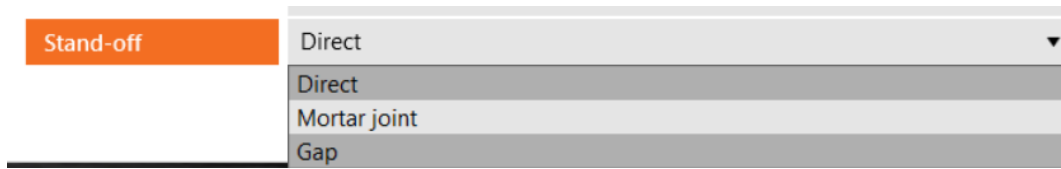
However, in the CBFEM analysis, the concrete block is modeled as a **shell element**



# Tension force by anchors

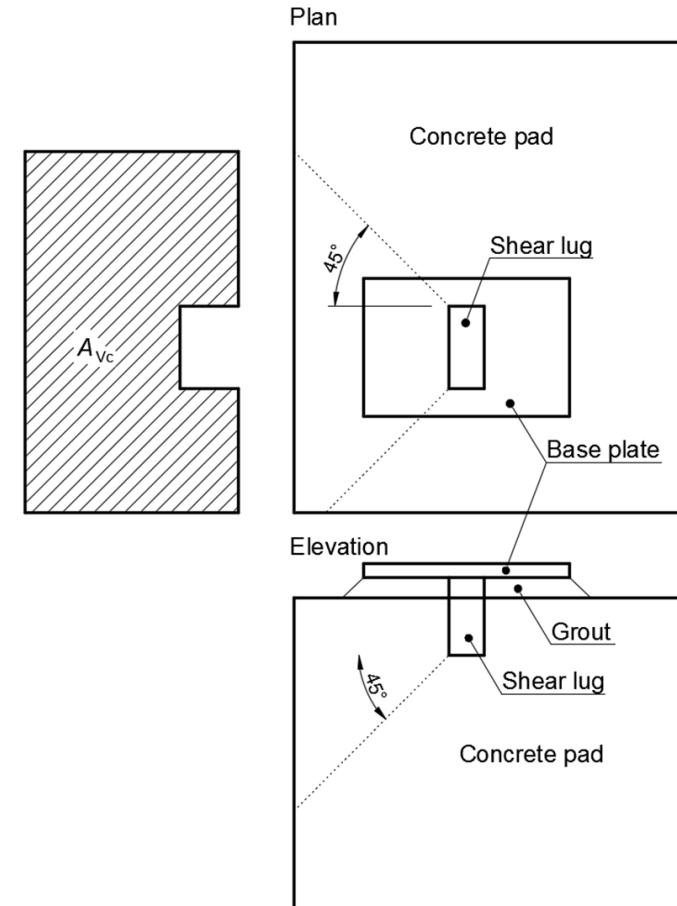
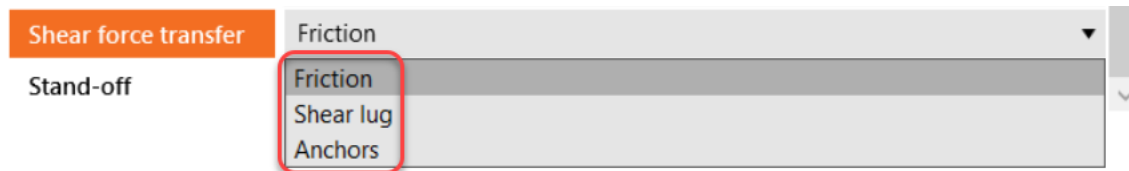


- Anchors are modeled as springs
- If a **gap** is selected, that portion is analyzed as a beam element
- **Gap** - Shear is transfer through anchors
- **Mortar** -Steel strength in shear  $V_{sa}$  is multiplied by 0.8 (ACI 318-14 – 17.5.1.3).



# 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

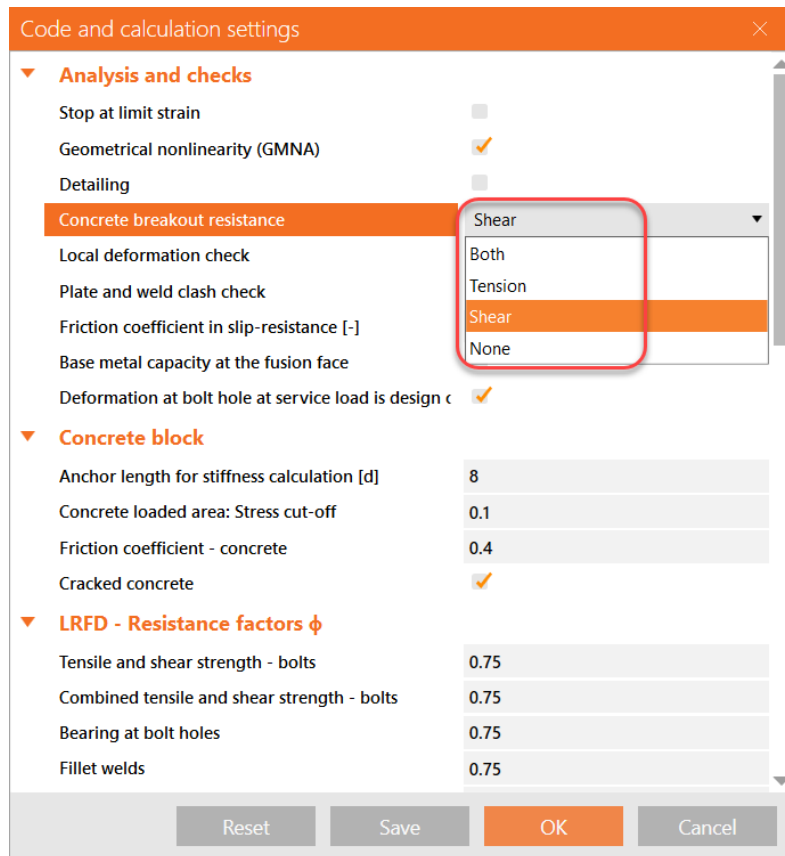
- Anchor rods are designed according to **AISC 360-16 – J9** and **ACI 318-14 – Chapter 17**.
- The following resistances of anchor bolts are evaluated:
  - Steel strength of anchor in tension  $\phi N_{sa}$ ,
  - Concrete breakout strength in tension  $\phi N_{cbg}$ ,
  - Concrete pullout strength  $\phi N_p$ ,
  - Concrete side-face blowout strength  $\phi N_{sb}$ ,
  - Steel strength of anchor in shear  $\phi V_{sa}$ ,
  - Concrete breakout strength in shear  $\phi V_{cbg}$ ,
  - Concrete pryout strength of anchor in shear  $\phi V_{cp}$ .

# Code check of Concrete blocks ACI

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

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

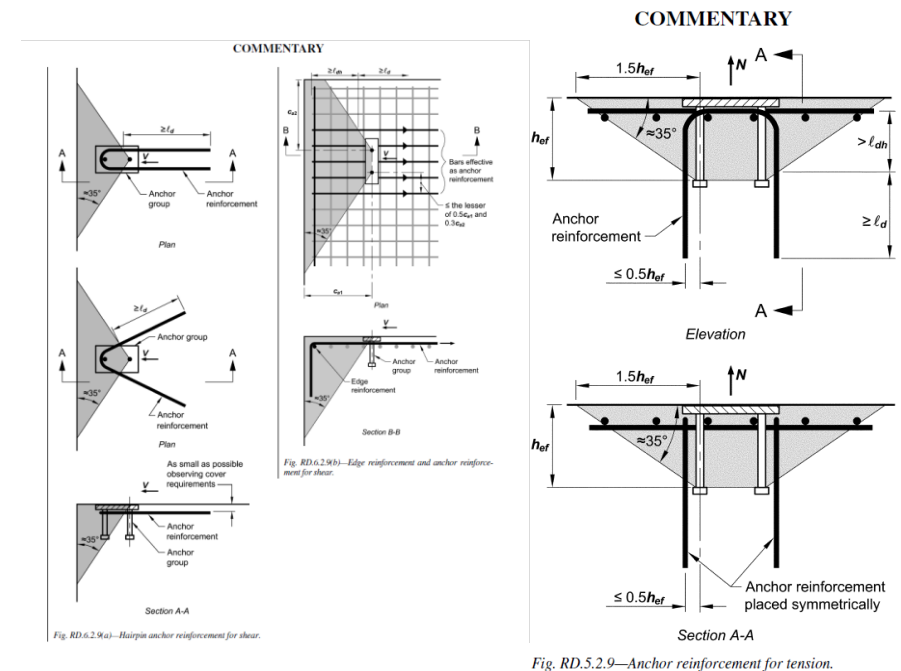
# Option to overpass the concrete breakout resistance as the user is adding supplementary reinforcement to the concrete block :



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?*

The screenshot displays the IdeaStatica software interface. On the left, a 3D model of a column connection is shown in a transparent view. The model includes a column (COL) and a base plate (BP1). Dimensions are visible: -67.44 and 5.9051.63. A production cost of 121 US\$ is indicated. The model is supported by four yellow bolts. A red dashed line outlines the connection area. A red box highlights the 'Weld1' option in the 'Operations' list.

Labels: Pictures | Connection Library | CBFEM | Solid | Transparent | Wireframe

Options | Import/Export loads | New

**Weld1** [General weld or contact] Copy Delete

- ▼ **General weld or contact**
  - Placement: Edge to surface
  - Type: **Contact**
- ▼ **First plate**
  - Member or plate: COL
- ▼ **Second plate**
  - Plate: BP1

**CON1**

- Members
  - ✓ COL
- Load effects
  - ✓ LE1
- Operations
  - BP1
  - ✓ **Weld1**

# 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?*

Production cost - 124 US\$

Status	Item	Edge	Xu	$t_w$ (in)	w (in)	L (in)	$L_e$ (in)	Loads	$F_a$ (kpl)	$\phi R_n$ (kpl)	Ut (%)
> +	BP1	COL	E70xx	1/4	5/16	3'-4 11/16	1/2	LE1	2.54	3.37	75.5
+ +			E70xx	1/4	5/16	3'-4 3/4	1/2	LE1	2.61	3.37	77.3

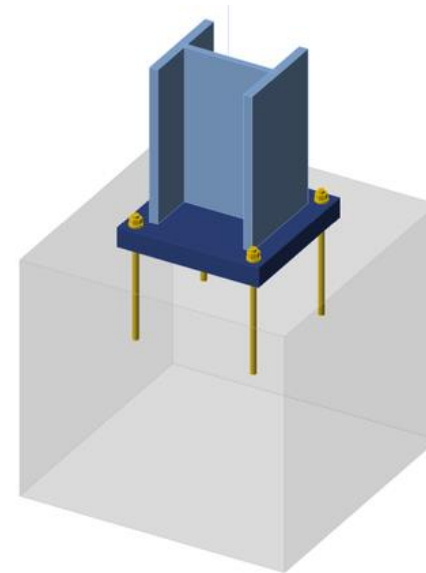
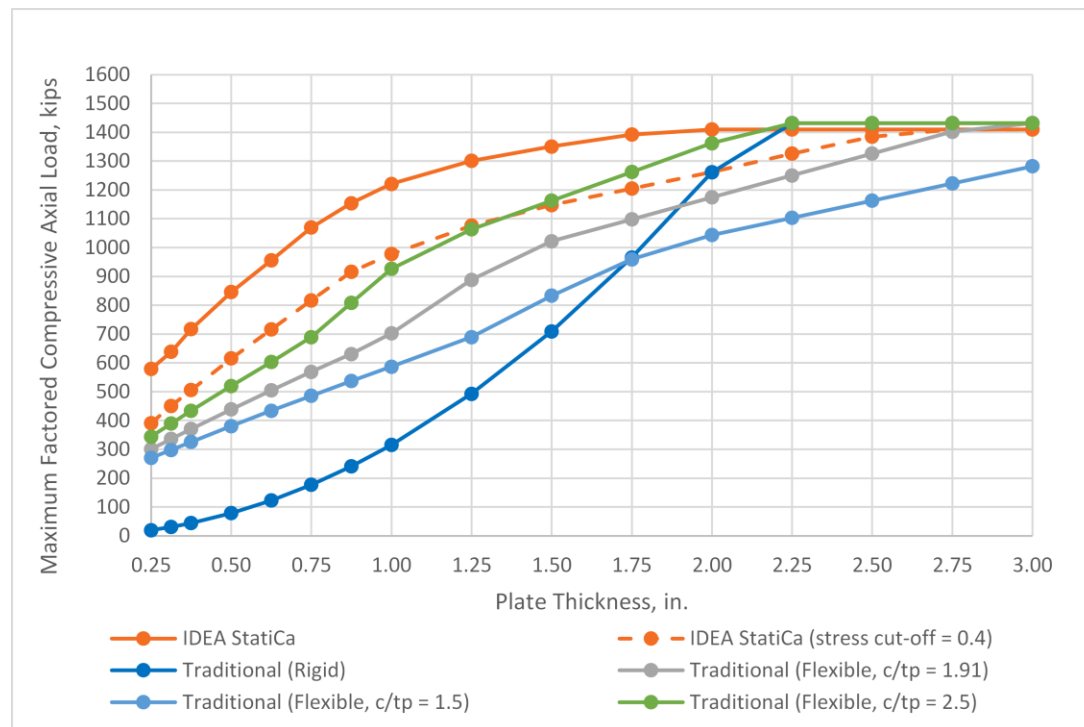
Production cost - 139 US\$

Status	Item	Edge	Xu	$t_w$ (in)	w (in)	L (in)	$L_e$ (in)	Loads	$F_a$ (kpl)	$\phi R_n$ (kpl)	Ut (%)
> +	BP1	COL	E70xx	1/4	5/16	3'-4 11/16	1/2	LE1	1.28	3.37	38.0
+ +			E70xx	1/4	5/16	3'-4 11/16	1/2	LE1	1.97	3.37	58.3

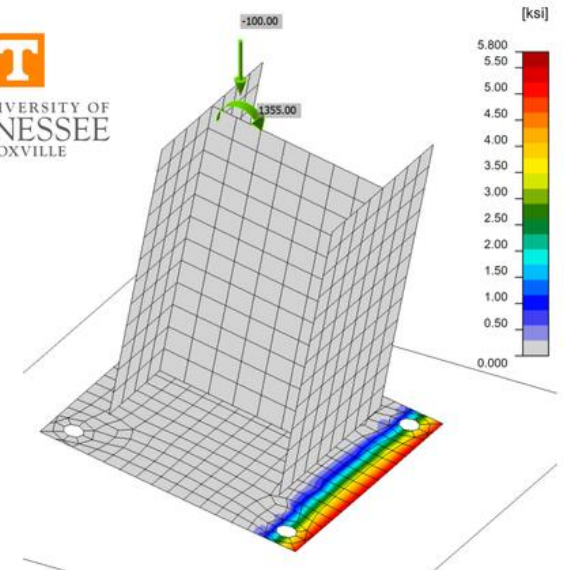
With extra contact



# Verification study: Base Plate Connections (AISC)

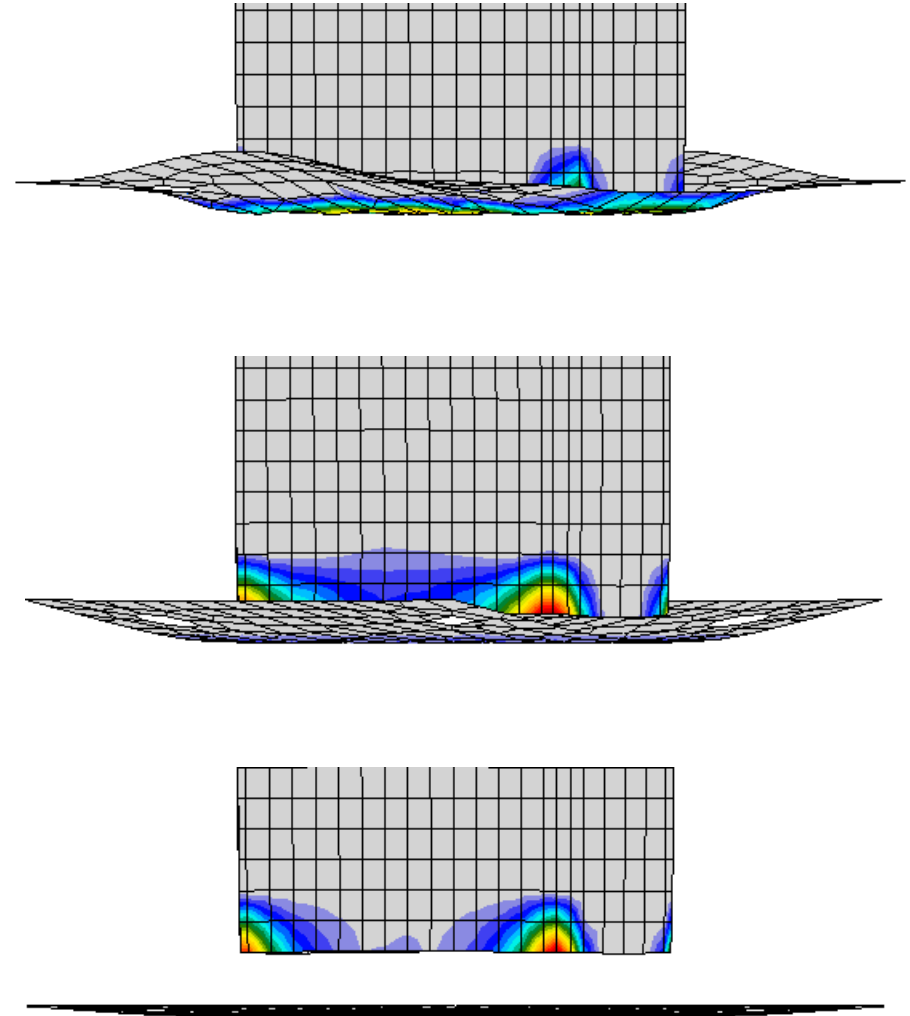
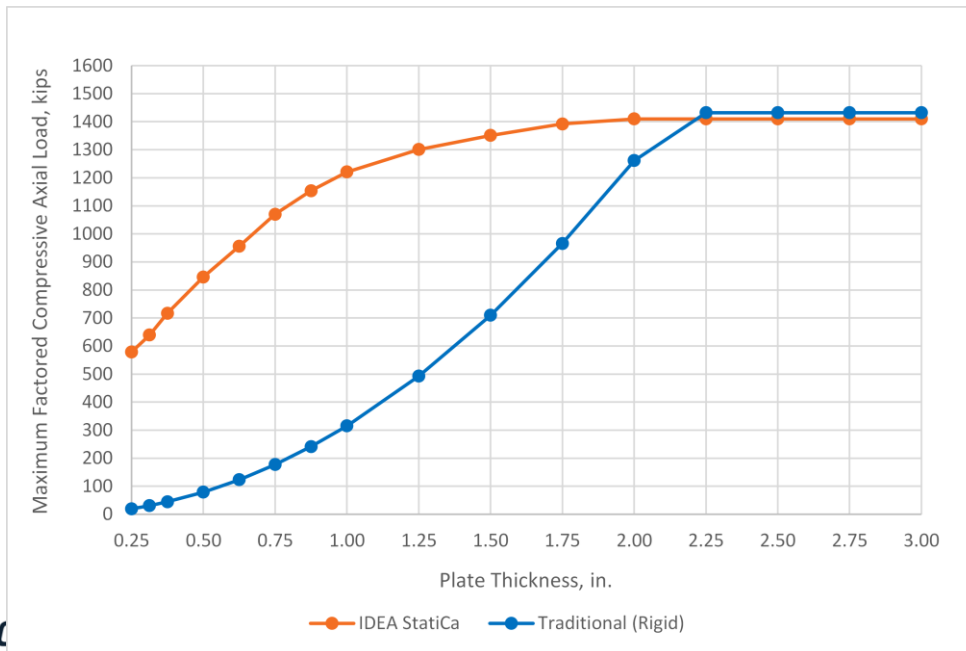


THE UNIVERSITY OF  
TENNESSEE  
KNOXVILLE



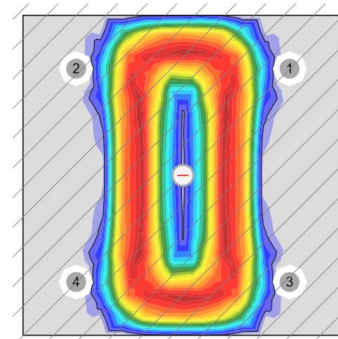
# Key findings

- 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.

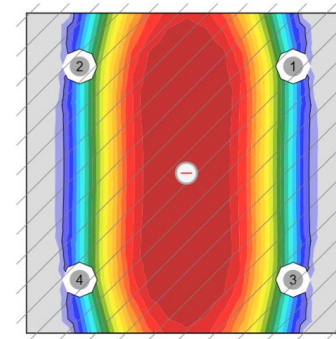


# Key findings

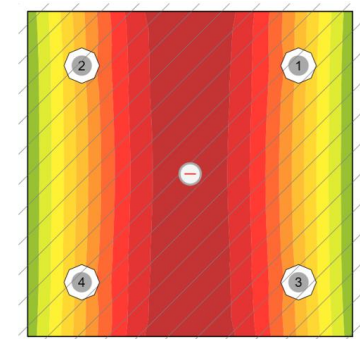
- For thinner base plates, where flexural yielding of the base plate due to bearing stresses controls, IDEA StatiCa can provide significantly greater strengths than the traditional calculations since the distribution of bearing stresses is calculated explicitly and redistributes upon the initiation of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



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



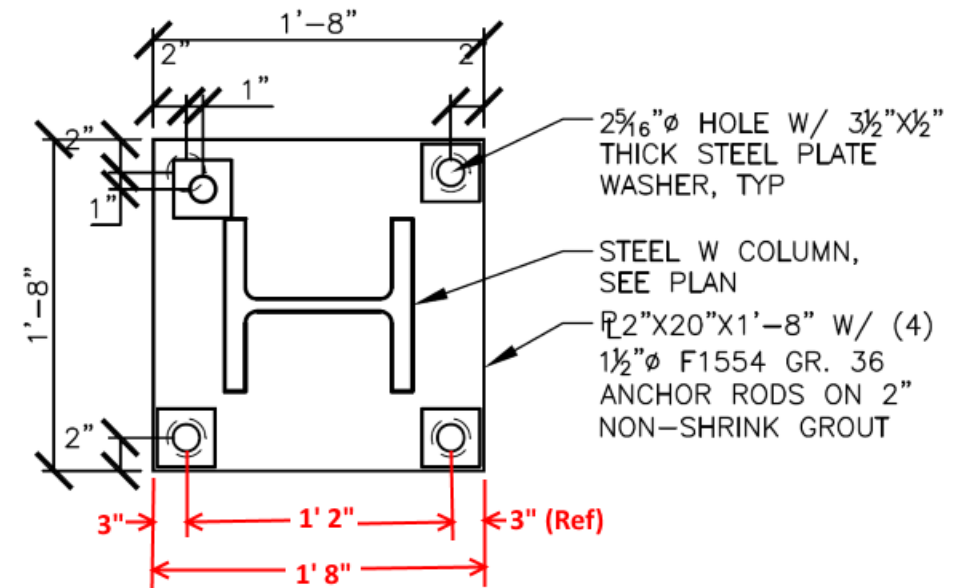
(b)  $t_p = 0.75$  in. and  $P = 458$   
kips



(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.