

Breaking down steel-to-concrete connection design and workflow limitations

November 2019



Meet the Speakers



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Agenda

- Challenges in steel-to-concrete (S2C) design workflow
- Solutions to workflow integration
- Solutions to design accuracy and productivity
- Q&A

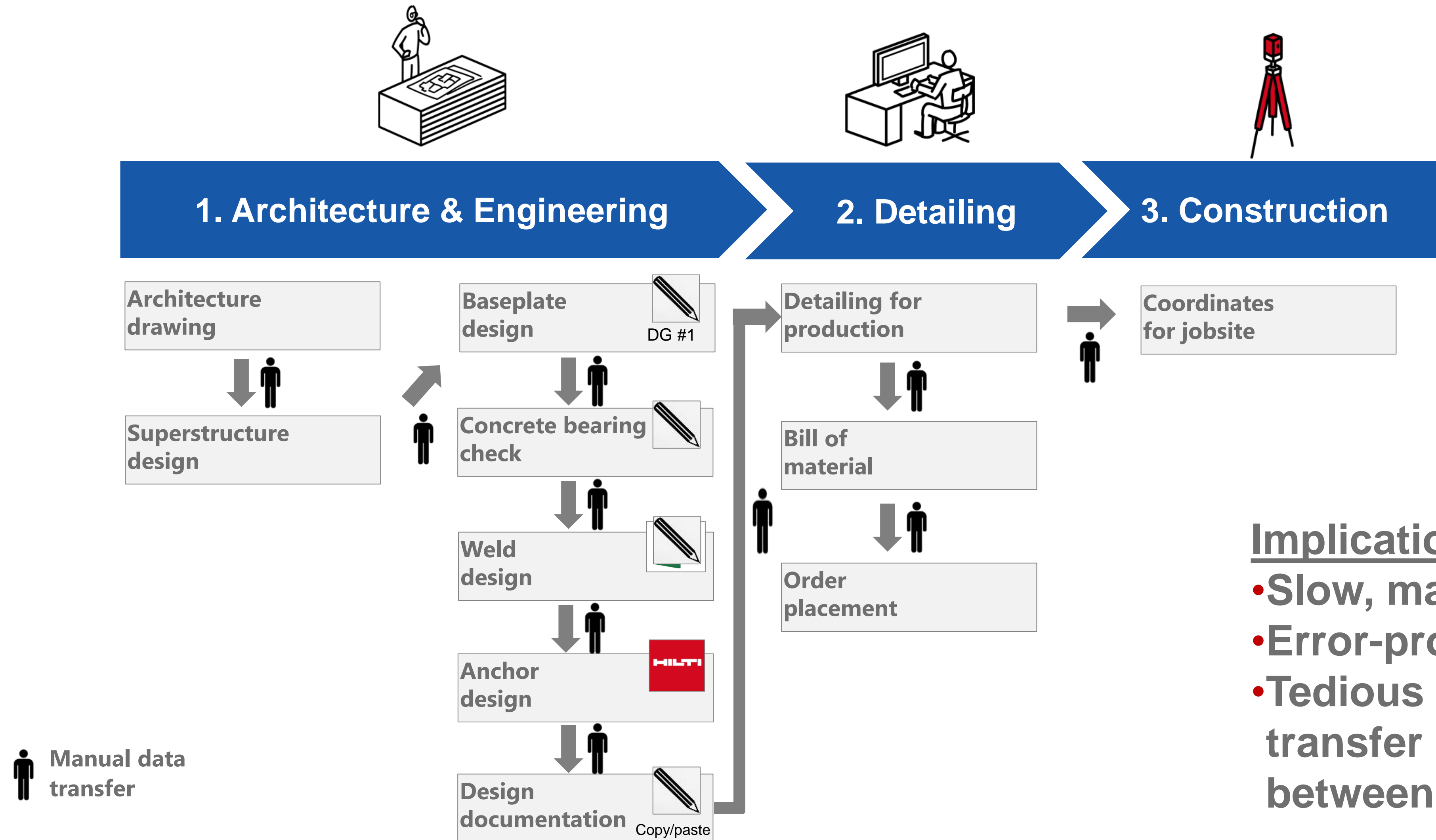
Software innovation, like almost every other kind of innovation, requires the ability to collaborate and share ideas with other people, and to sit down and talk with customers and get their feedback and understand their needs.

Bill Gates

Challenges in design and modeling of S2C connections



Current design workflow



Implications

- Slow, manual work
- Error-prone
- Tedious and inefficient transfer of information between systems

All mentioned software packages are examples

Challenges in current S2C design process

- User must select the governing load combination prior
- Different methods/tools need to be used to design one connection
 - Multiple points of manual data transfer
 - Design assumptions may conflict
- Tedious and error-prone process
- Significant effort required to implement changes



Source:
<https://i.pinimg.com/originals/f3/57/a7/f357a7360ac0e3b12dba2e1b2a85848b.jpg>

What else is limiting your S2C designs?

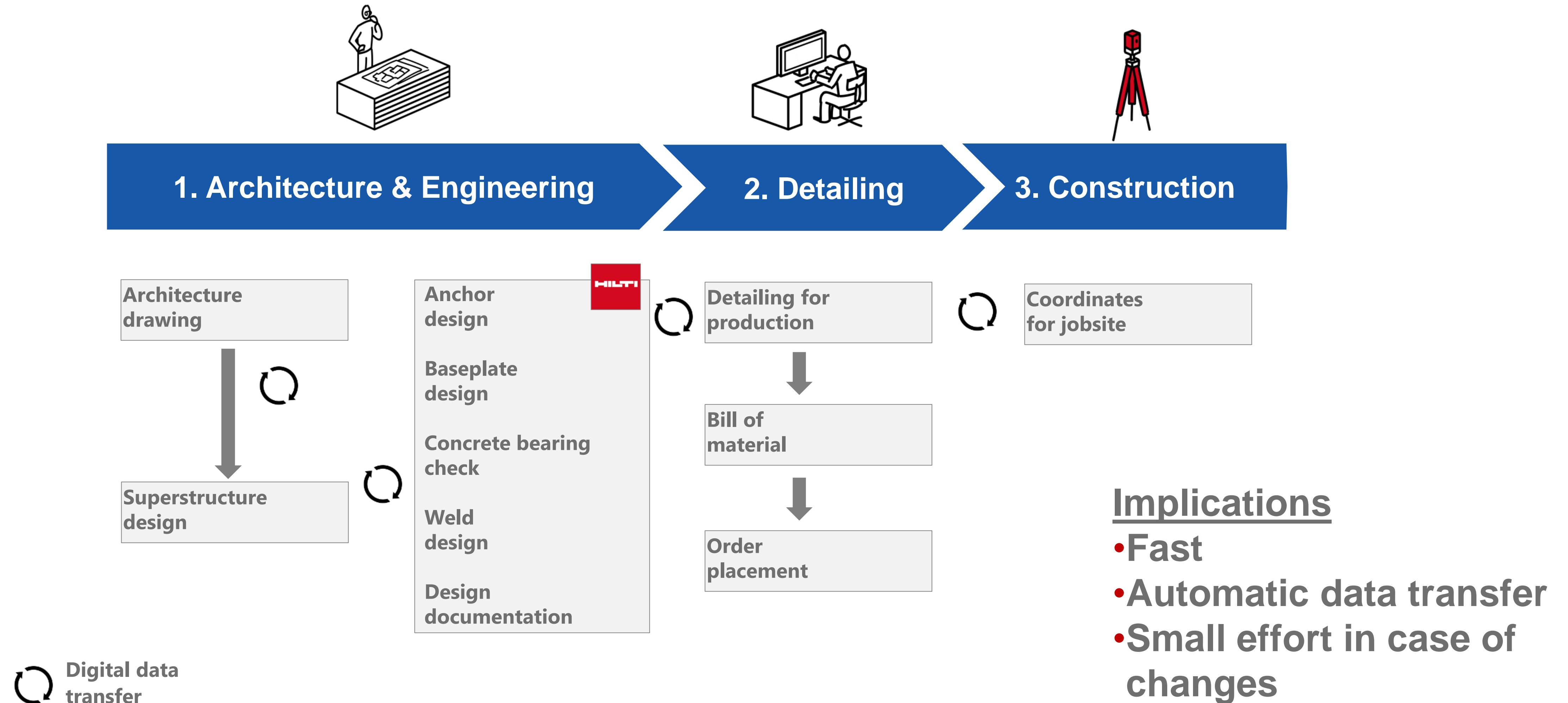
**What else is limiting your
S2C designs?**

**Remember Bill Gates' quote
– we are here to get your
feedback and understand
your needs!**

Solutions for workflow integration

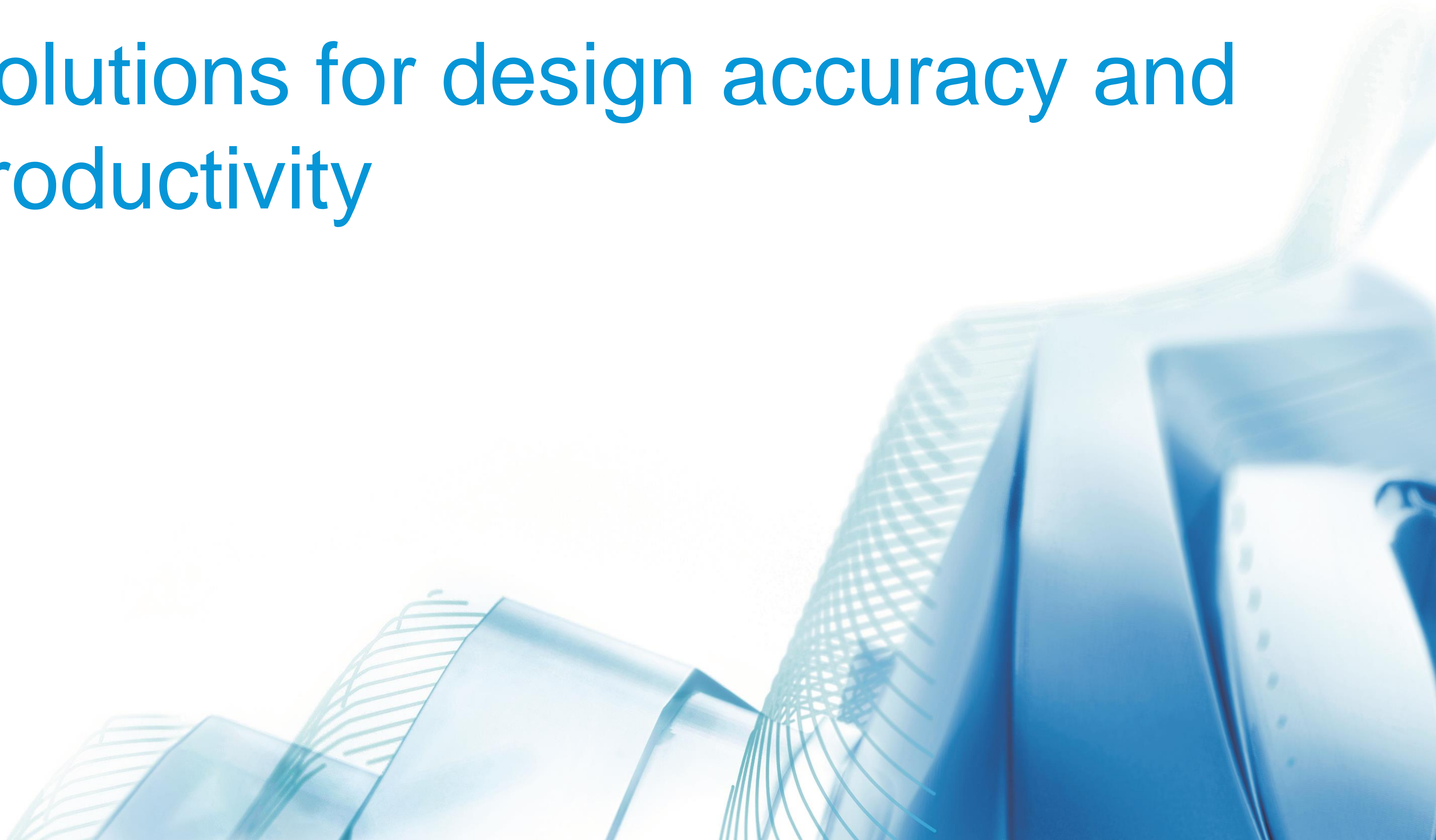


Solutions for design workflow integration



All mentioned software packages are examples

Solutions for design accuracy and productivity



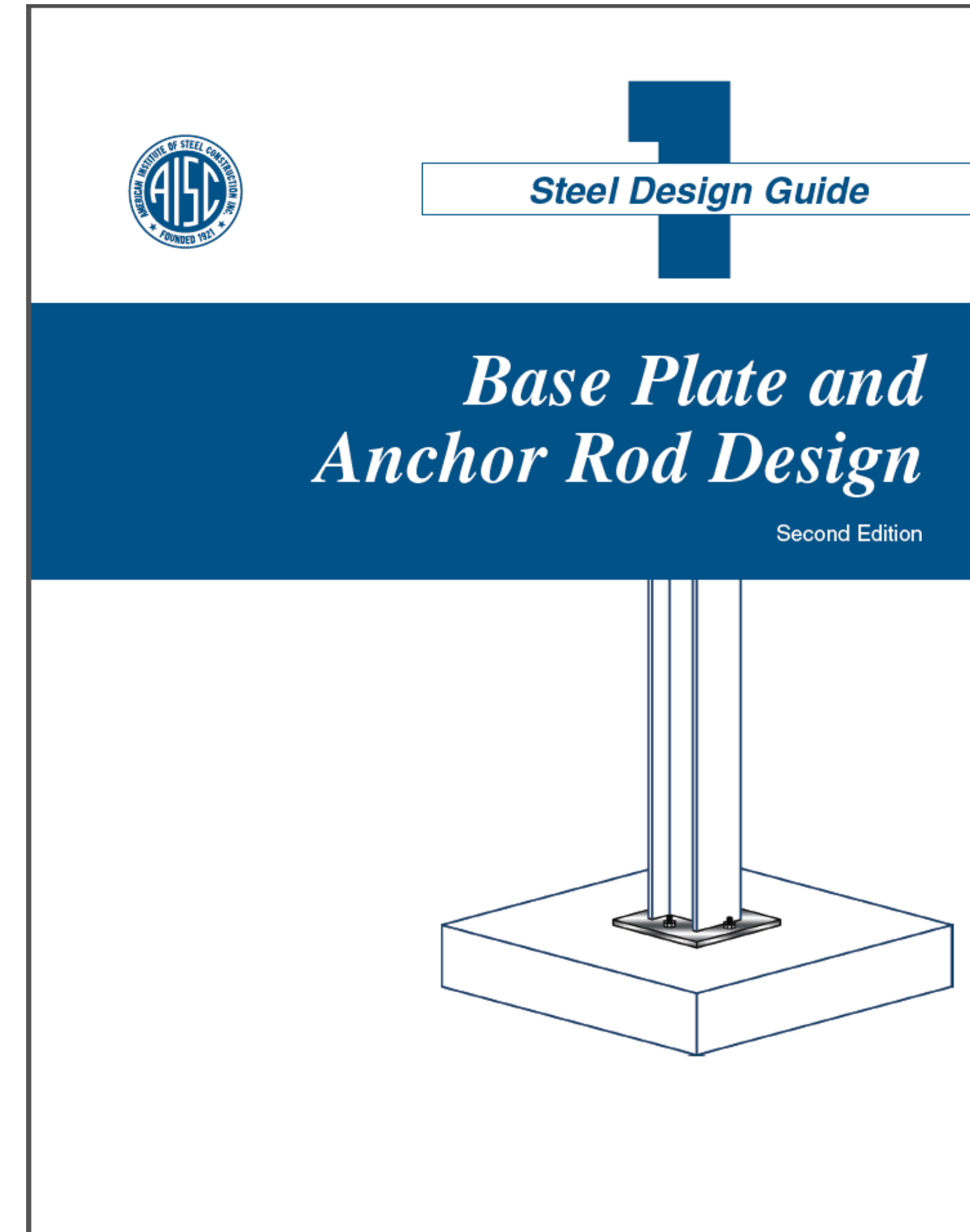
How do you design base plates?

AISC Design Guide 1

AISC Design Guide 1, 2nd Edition is a code-based design methodology for base plate and anchor rods that is comprised of algebraic formulas that are easy to execute for simple conditions.

Scope:

- Concentric Compressive Axial Loads (section 3.1)
- Tensile Axial Loads (section 3.2)
- Base Plates with Small Moments (section 3.3)
- Base Plates with Large Moments (section 3.4)
- Design for Shear (section 3.5)



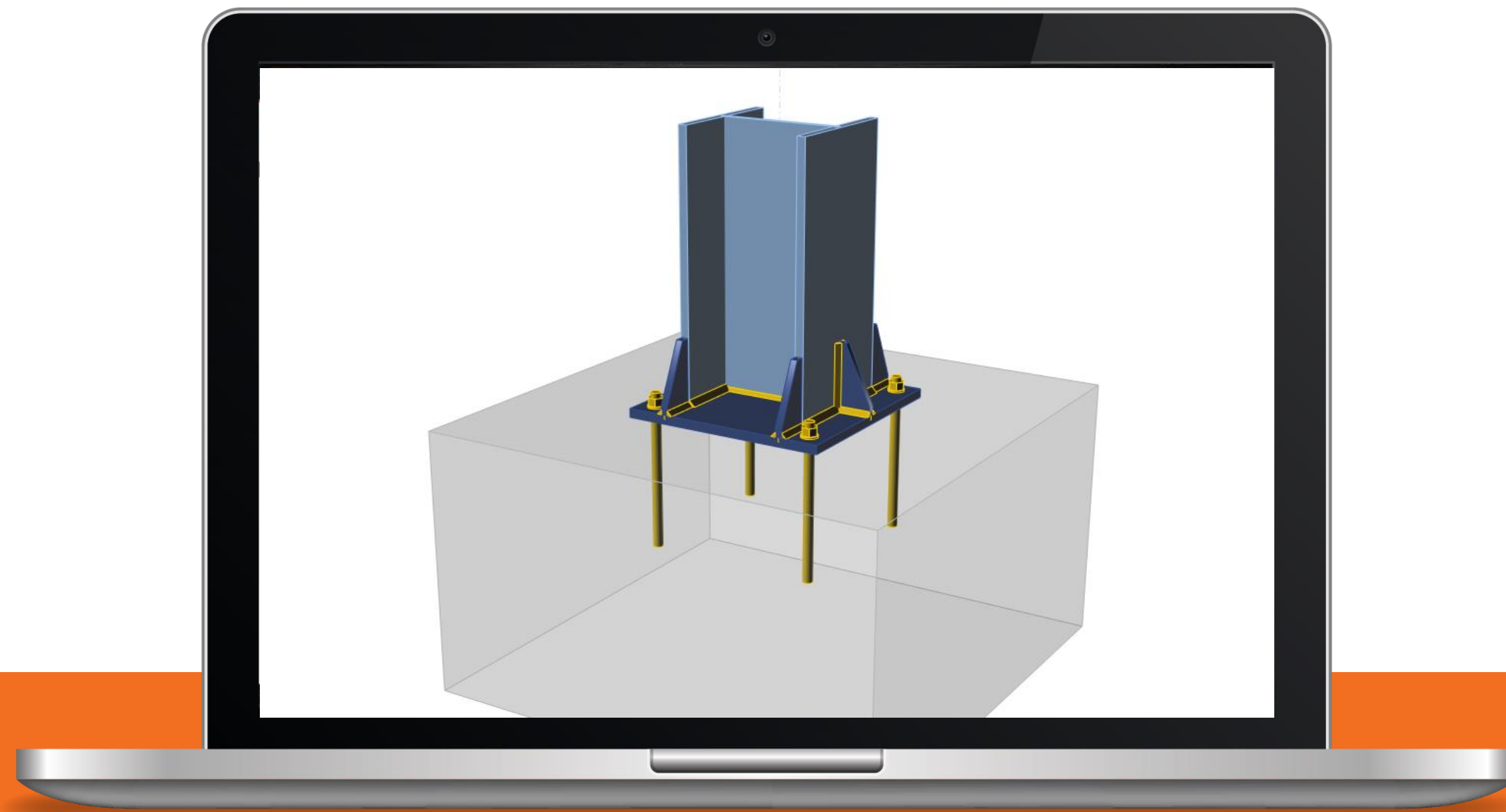
When things “aren’t so simple”

- Anchor design code ACI 318 requires rigid base plate
 - How to ensure you comply with this requirement?
- Rigid base plate as a theoretical term vs. reality
 - When is a base plate considered rigid?
 - See the effects live!
- Cases not covered by AISC DG1 (loading, geometry, ...)
 - How to design?
- Parameters influencing each other
 - How to make sure the dependencies are accounted for?



**How do you design your
base plate in these cases?**

The best way to solve these cases? **CBFEM.**
(Component-Based Finite Element Method)



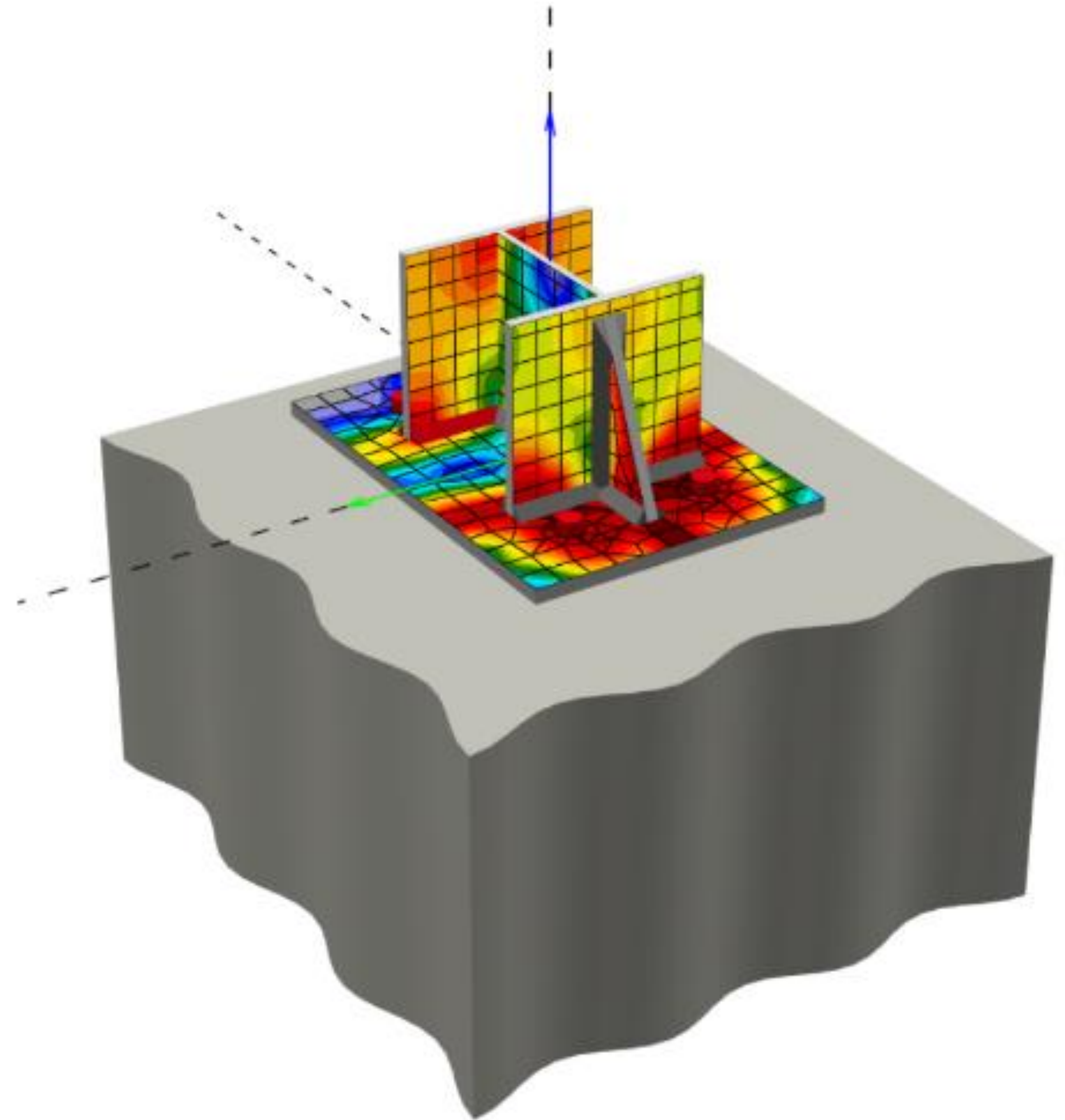
**Benefits, approach, theory, model, verification,
validation.**

Intro to CBFEM

- The method for design and validation of steel connections and anchoring by finite elements.
- All checks according to the code (same as the Component method).
- Any topology, any loading, in minutes

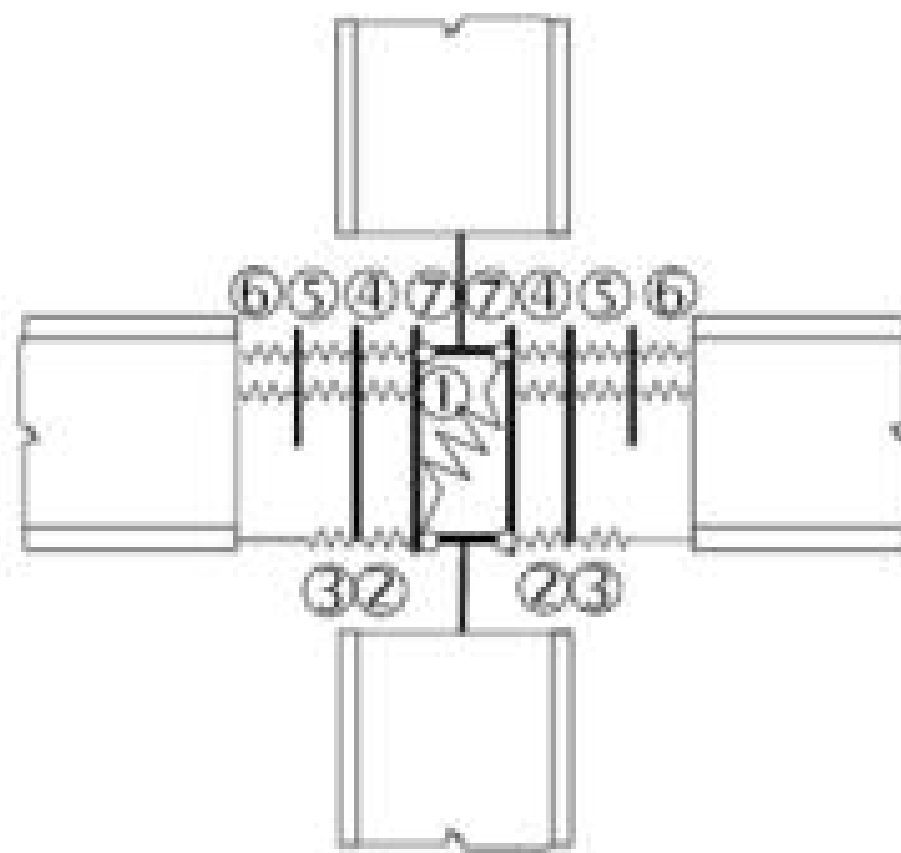
Why was it created?

Structural engineers needed a tool for efficient analysis and code-compliance validation.

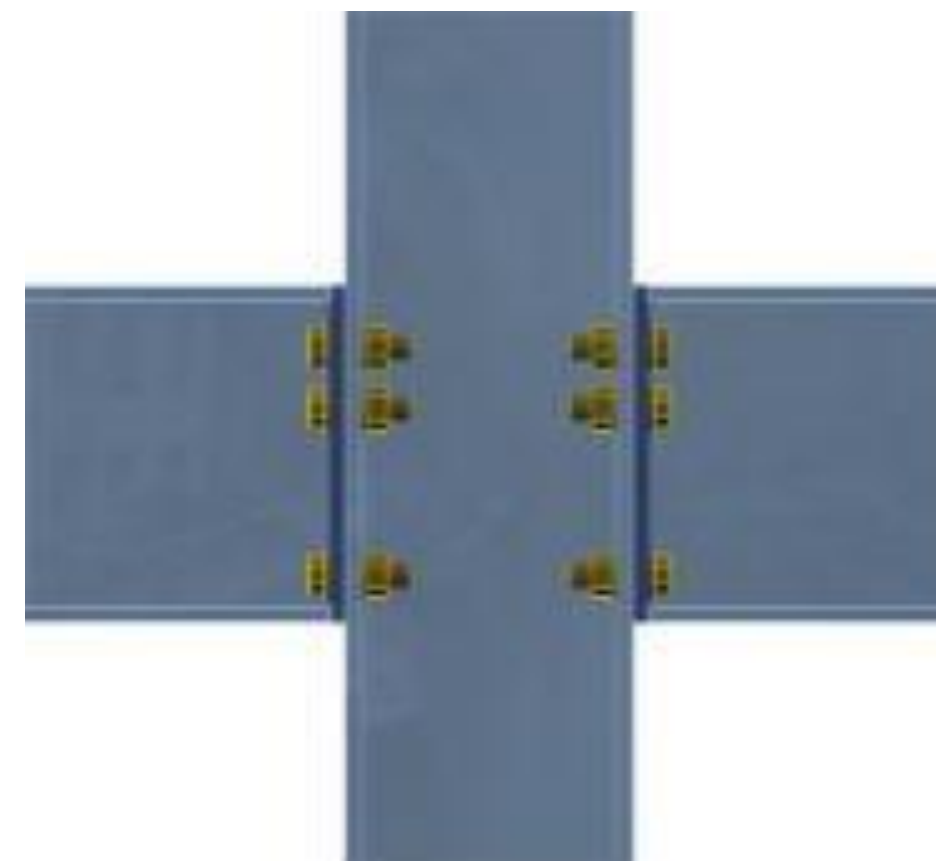


How Did We Figure It Out?

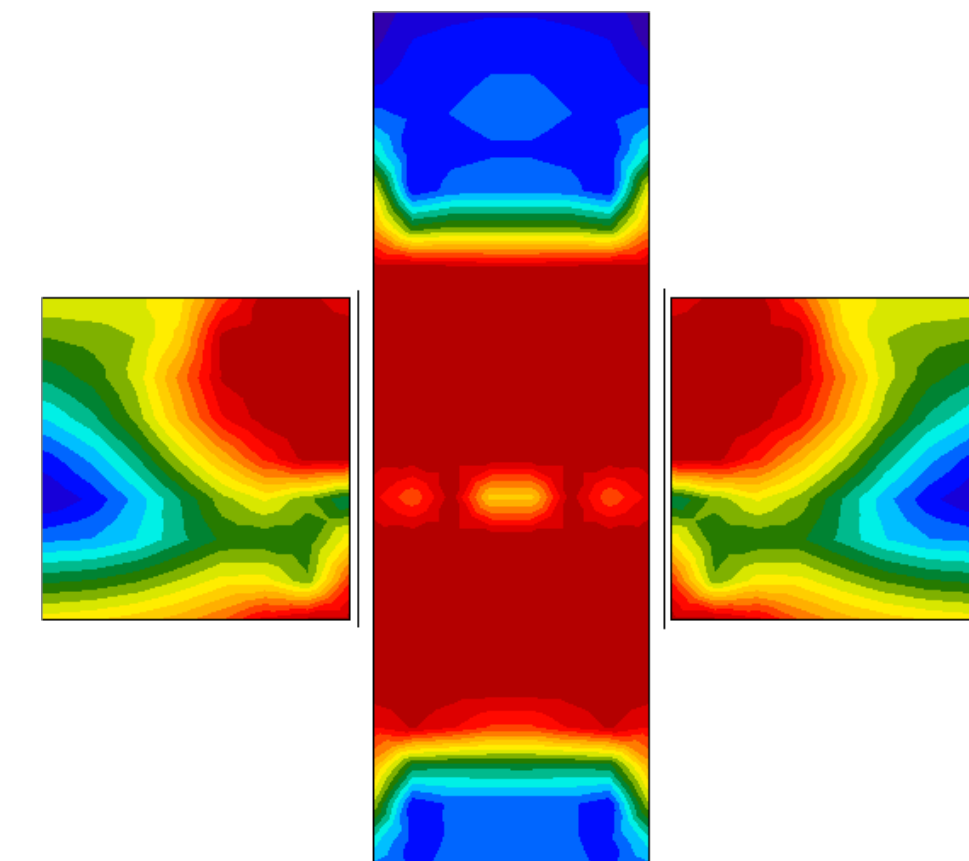
CBFEM is synergy of Component method and FE analysis.



Component Model



← **Bolted Connection** →

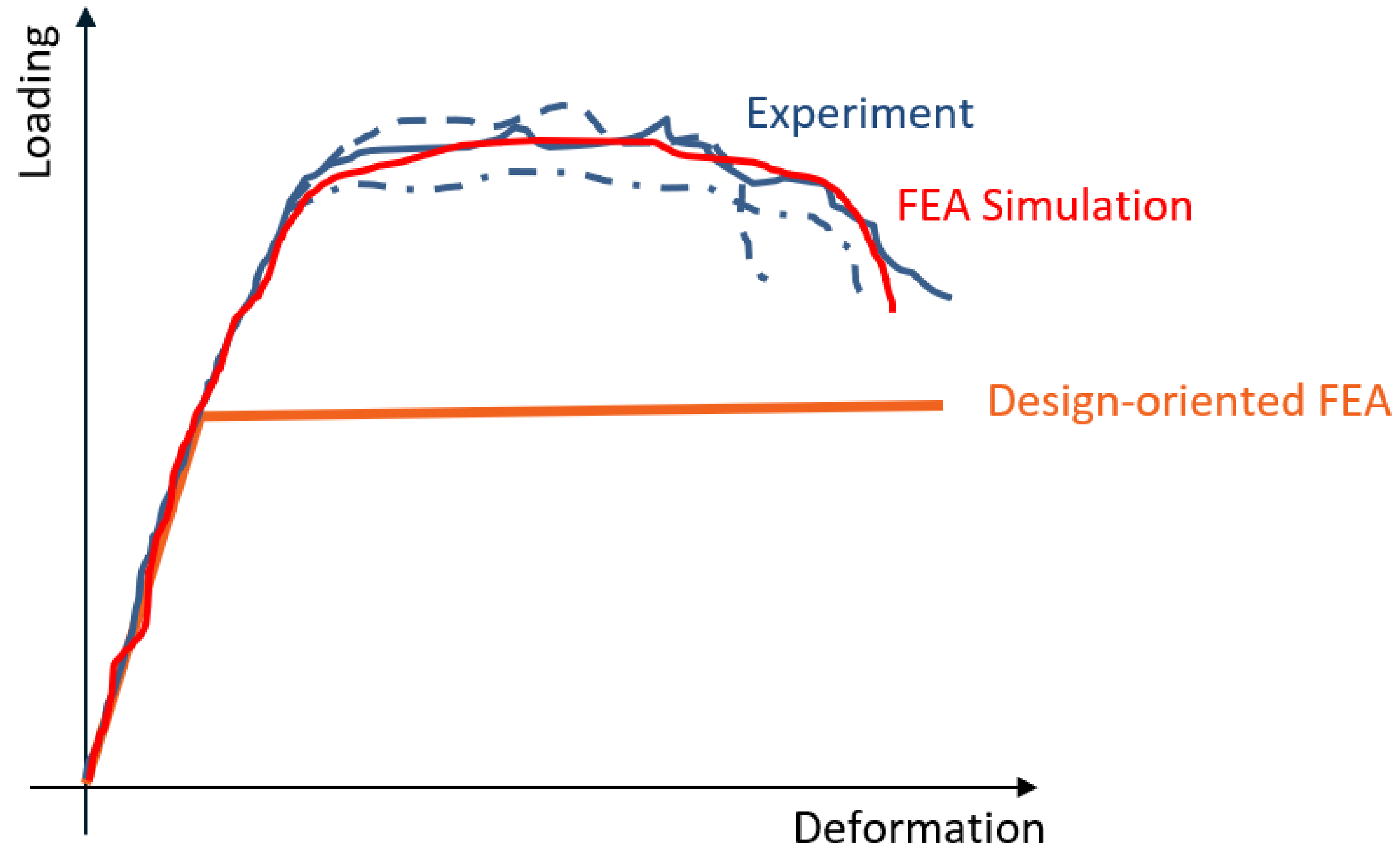


CBFEM model



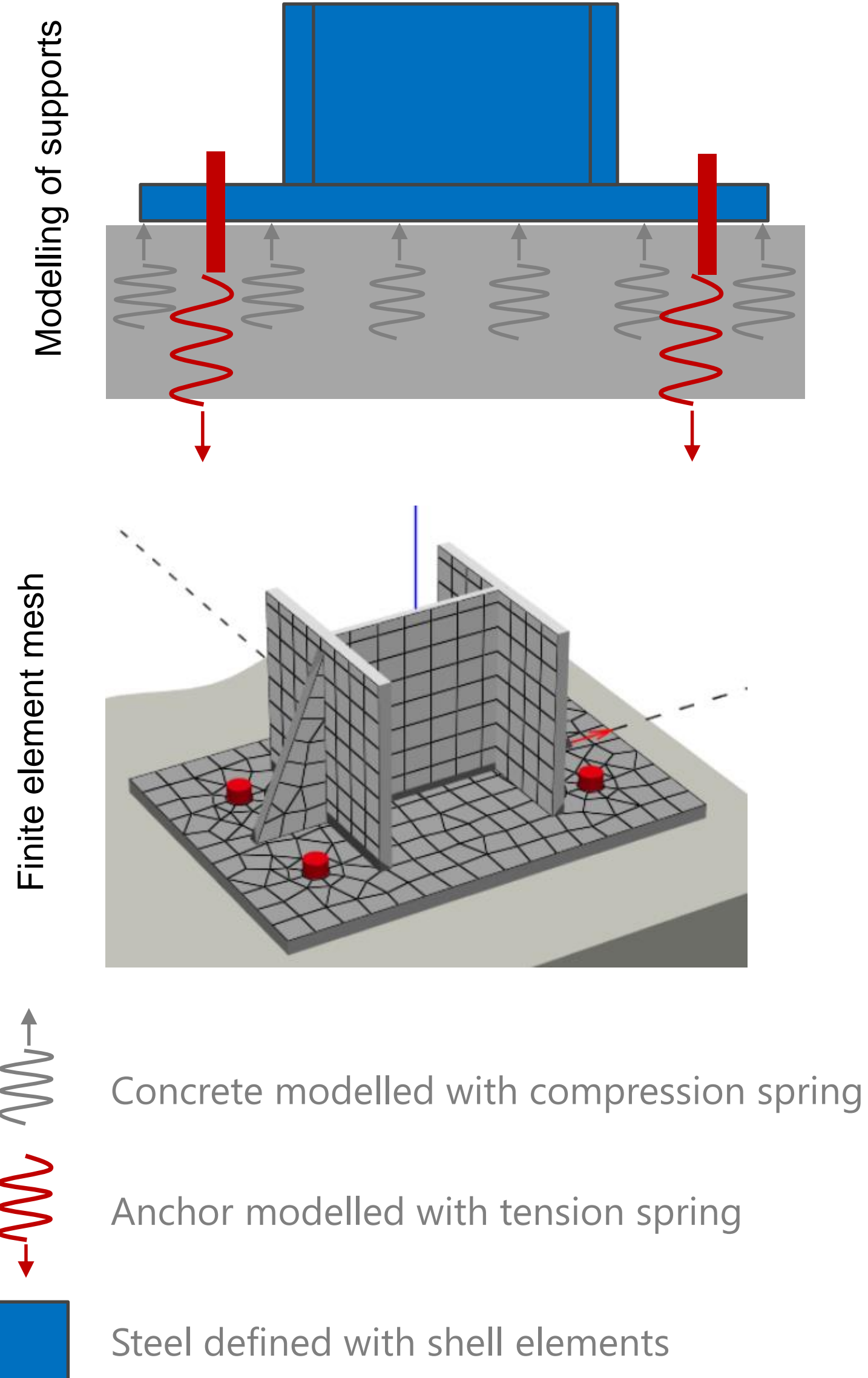
The Basis

Design-oriented FEA is optimized to deliver results relevant for code-check rather than exact simulations of behavior in extreme case.

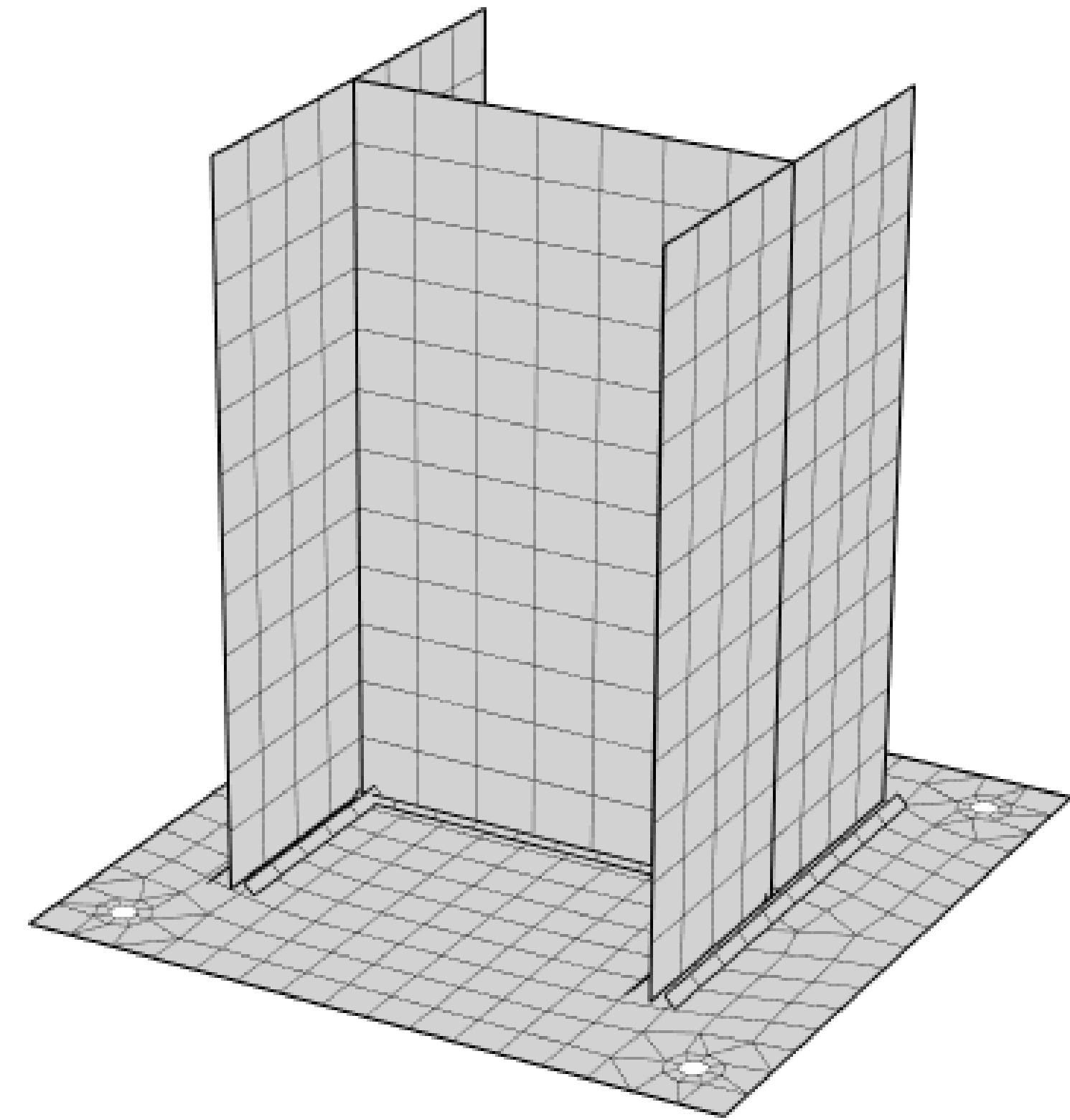
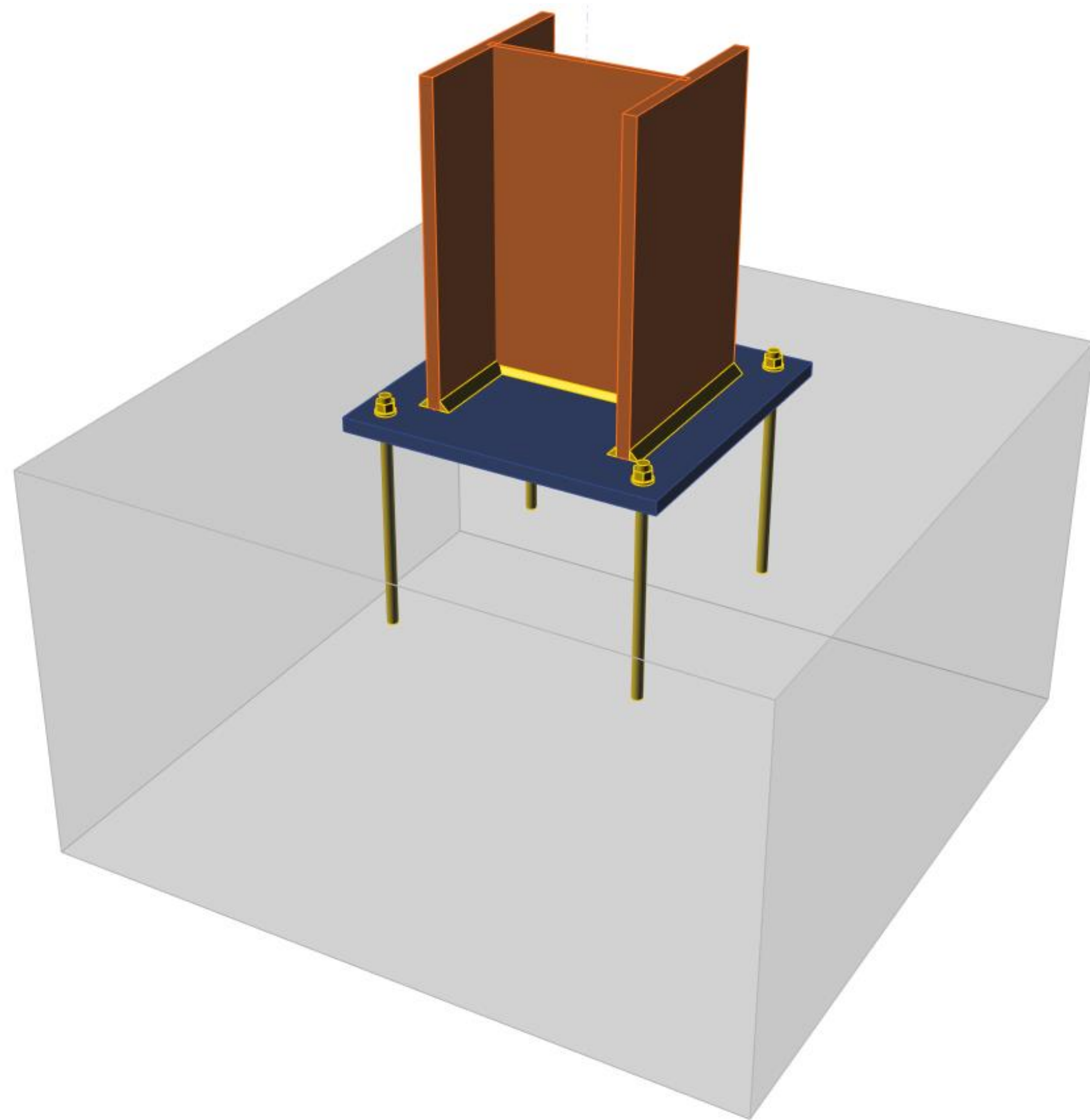


Key Features of CBFEM

- Finite Element model created for each component
 - Member
 - Plate
 - Weld
 - Anchor
- Analysis model **created automatically** from each component
 - No user input needed
- Analysis performed
 - Material nonlinearity
 - Geometrical nonlinearity

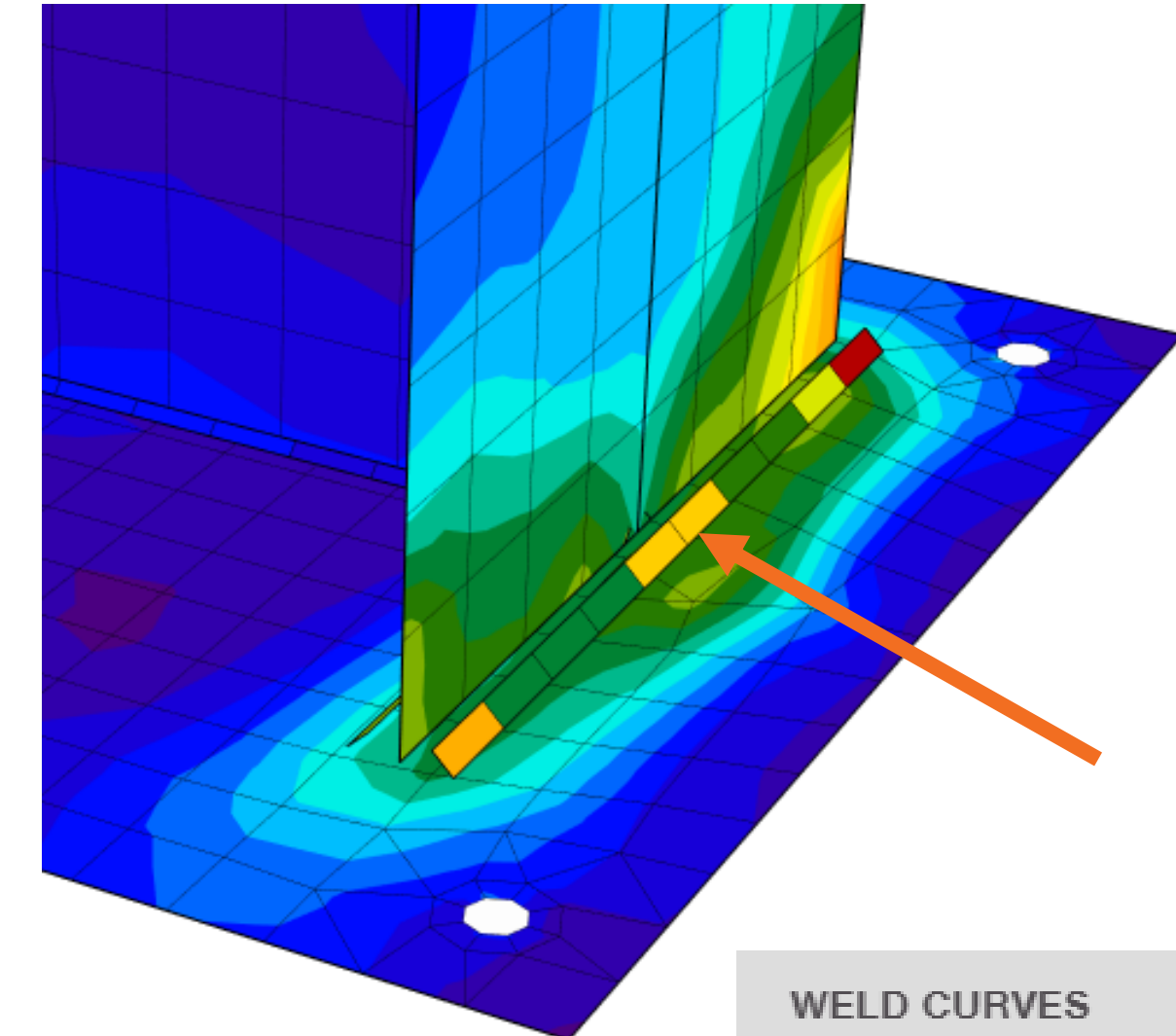
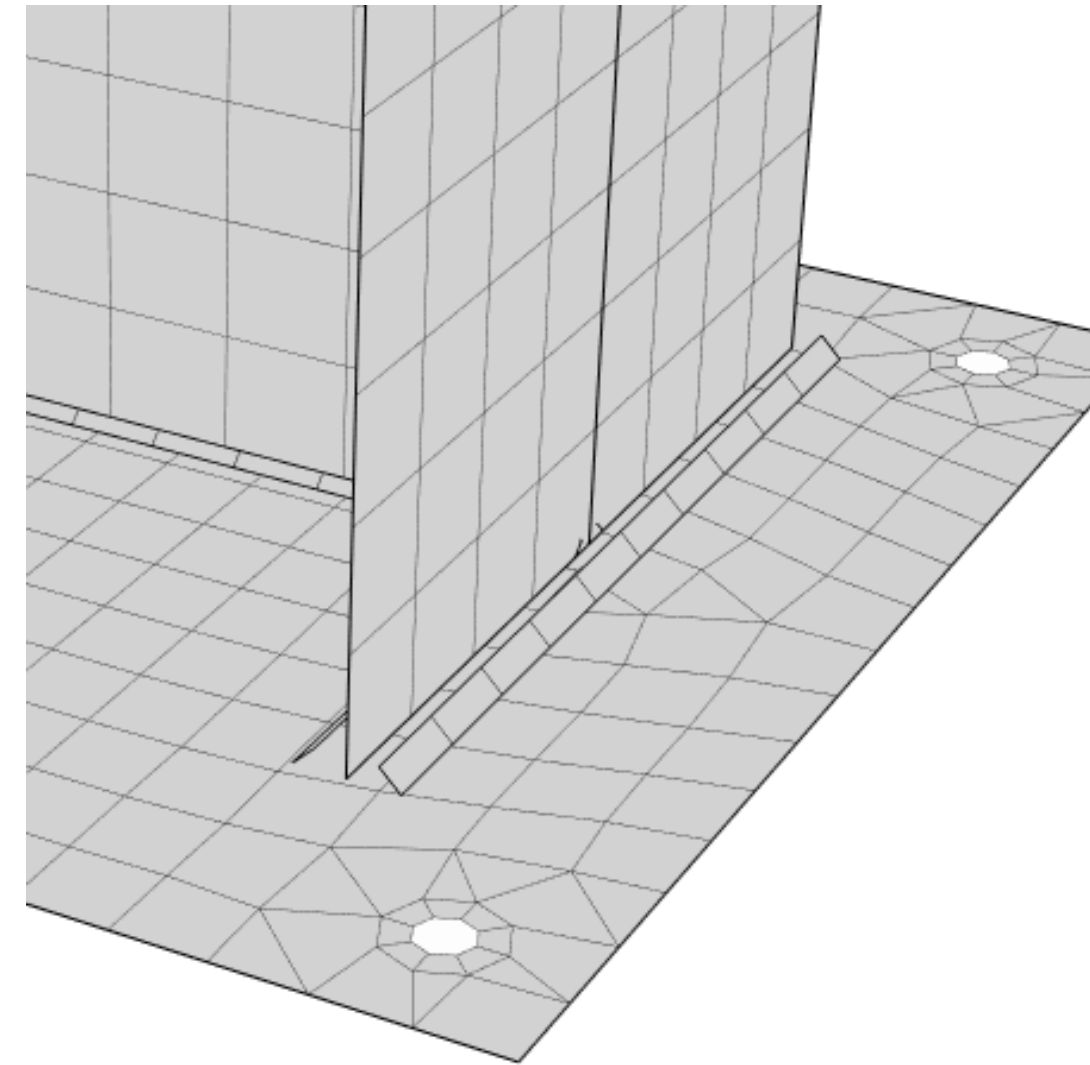
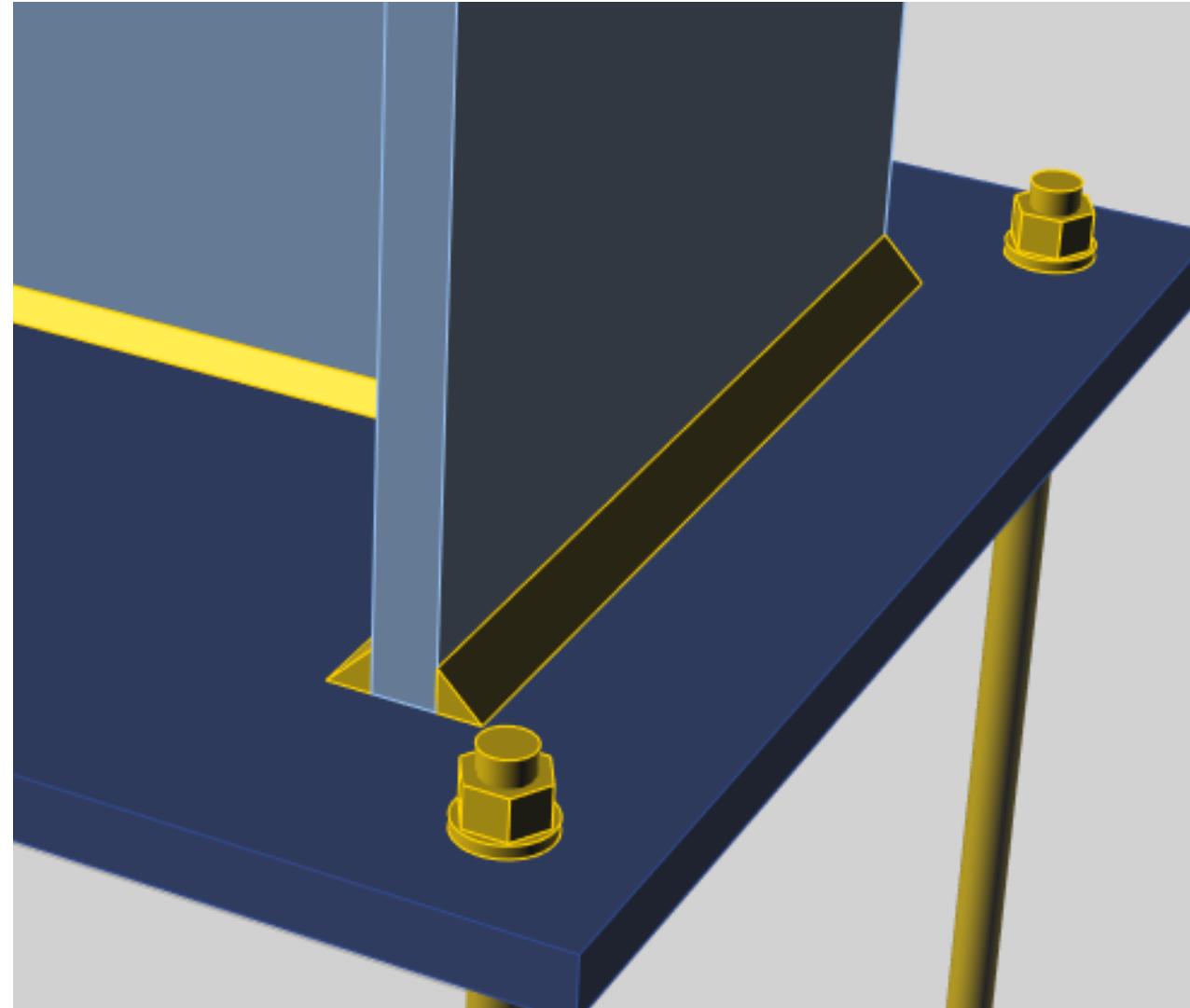


Member and Plate (CBFEM)



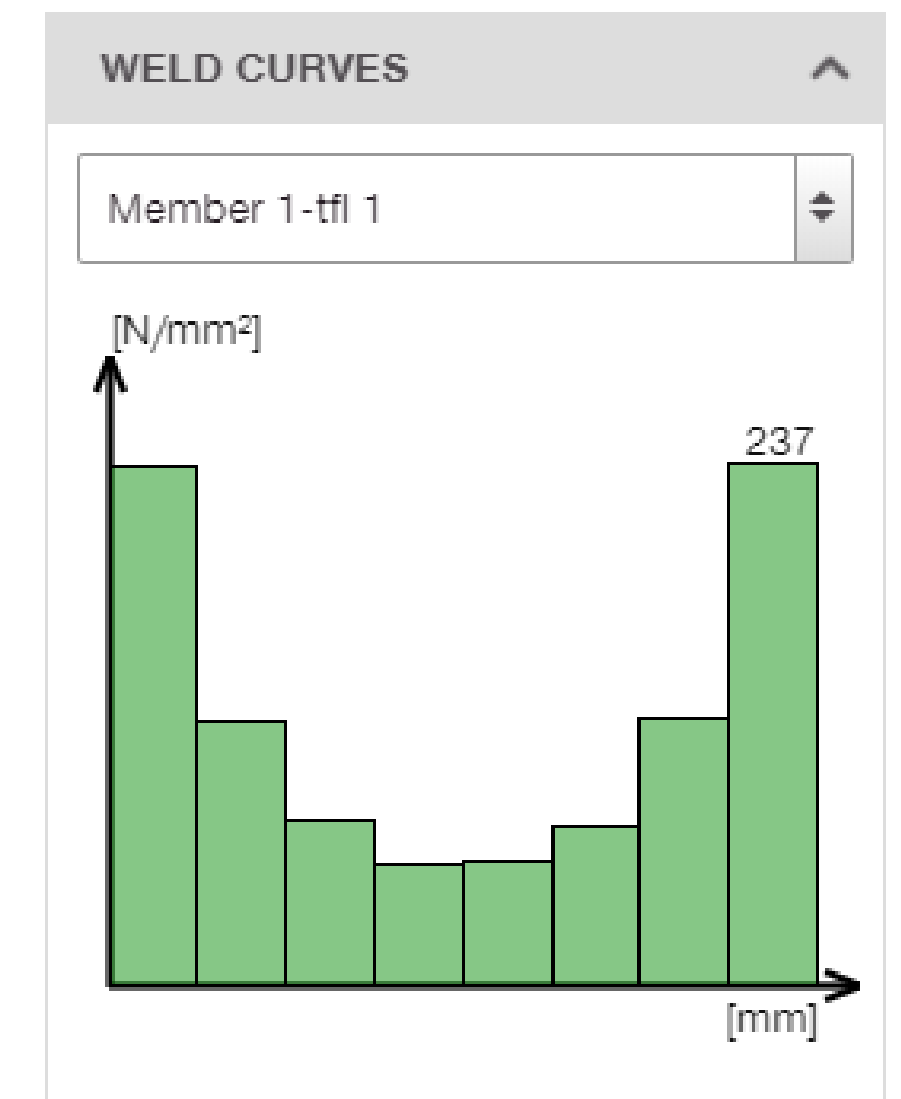
Member, plate = Shell element

Welds (CBFEM)



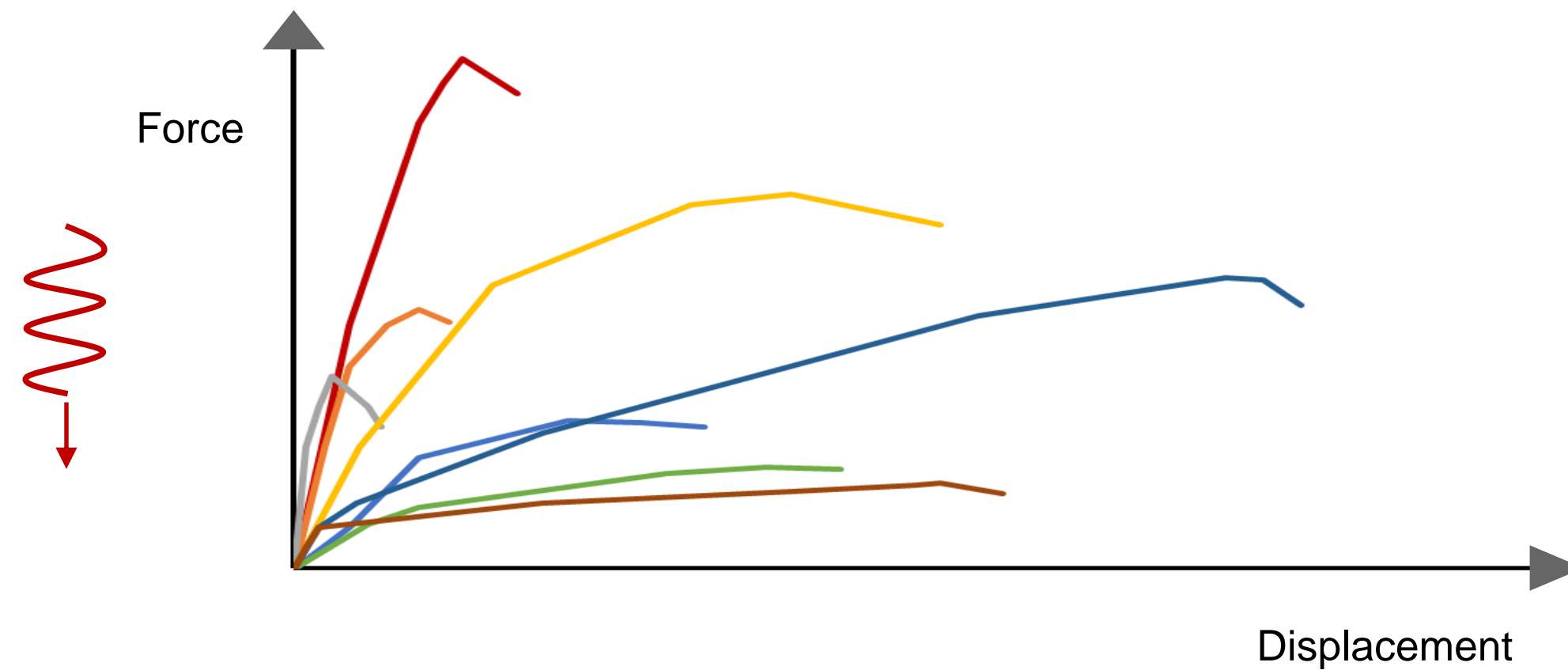
Weld element

- Real behavior of weld – special FE element
- Redistribution of the stress along the weld
- Stiffness of the weld
- Ductility

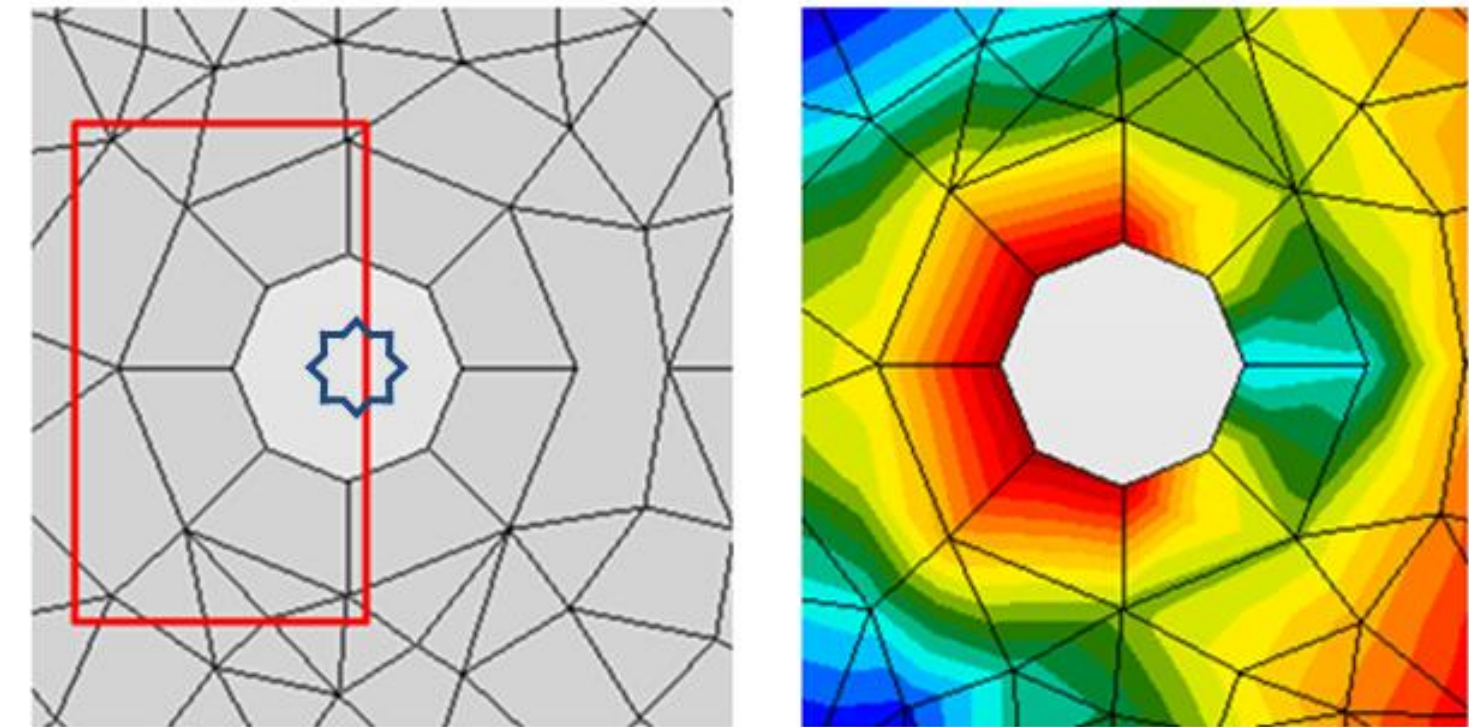


Anchor Model (CBFEM)

Tension: non-linear springs

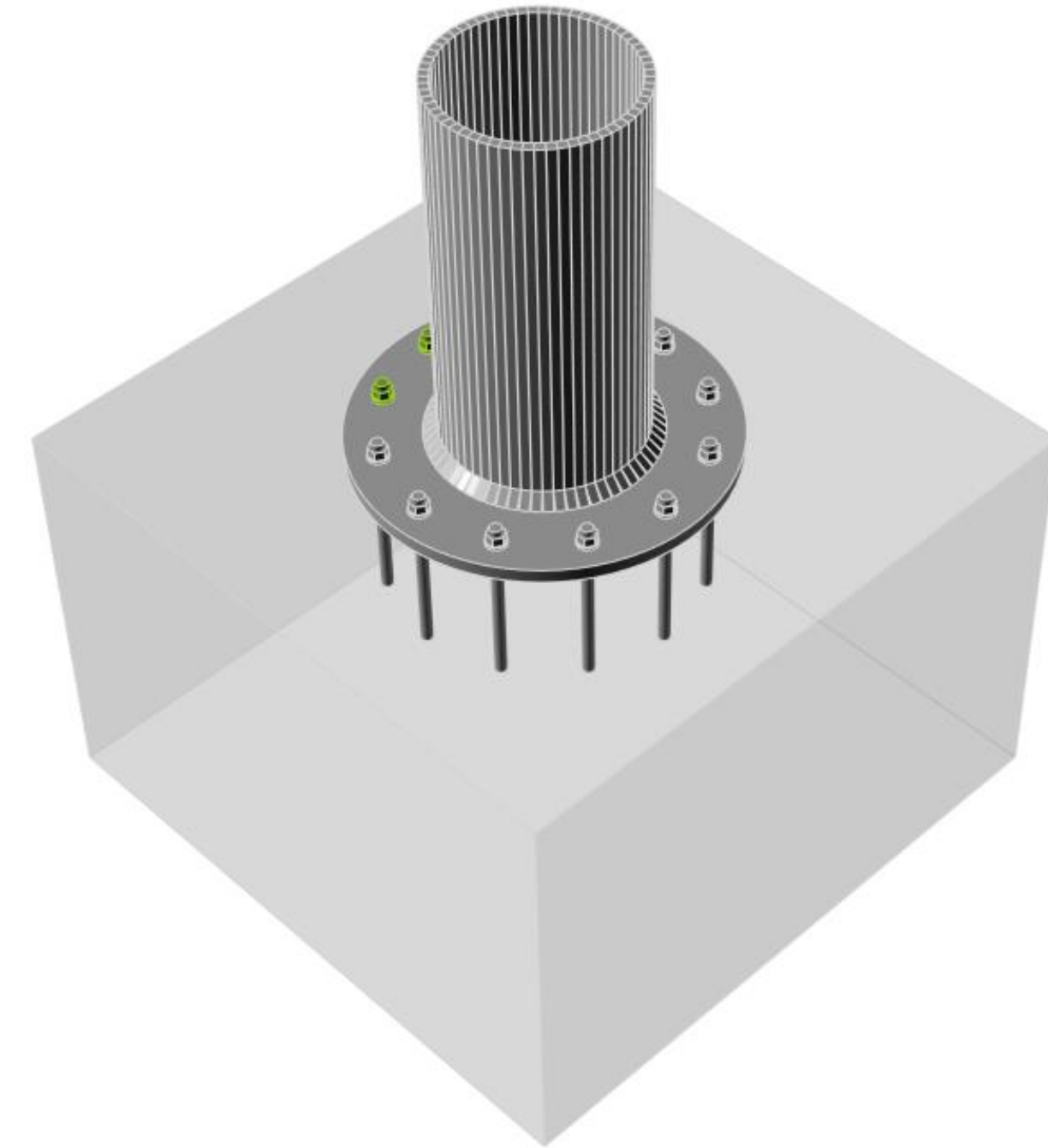
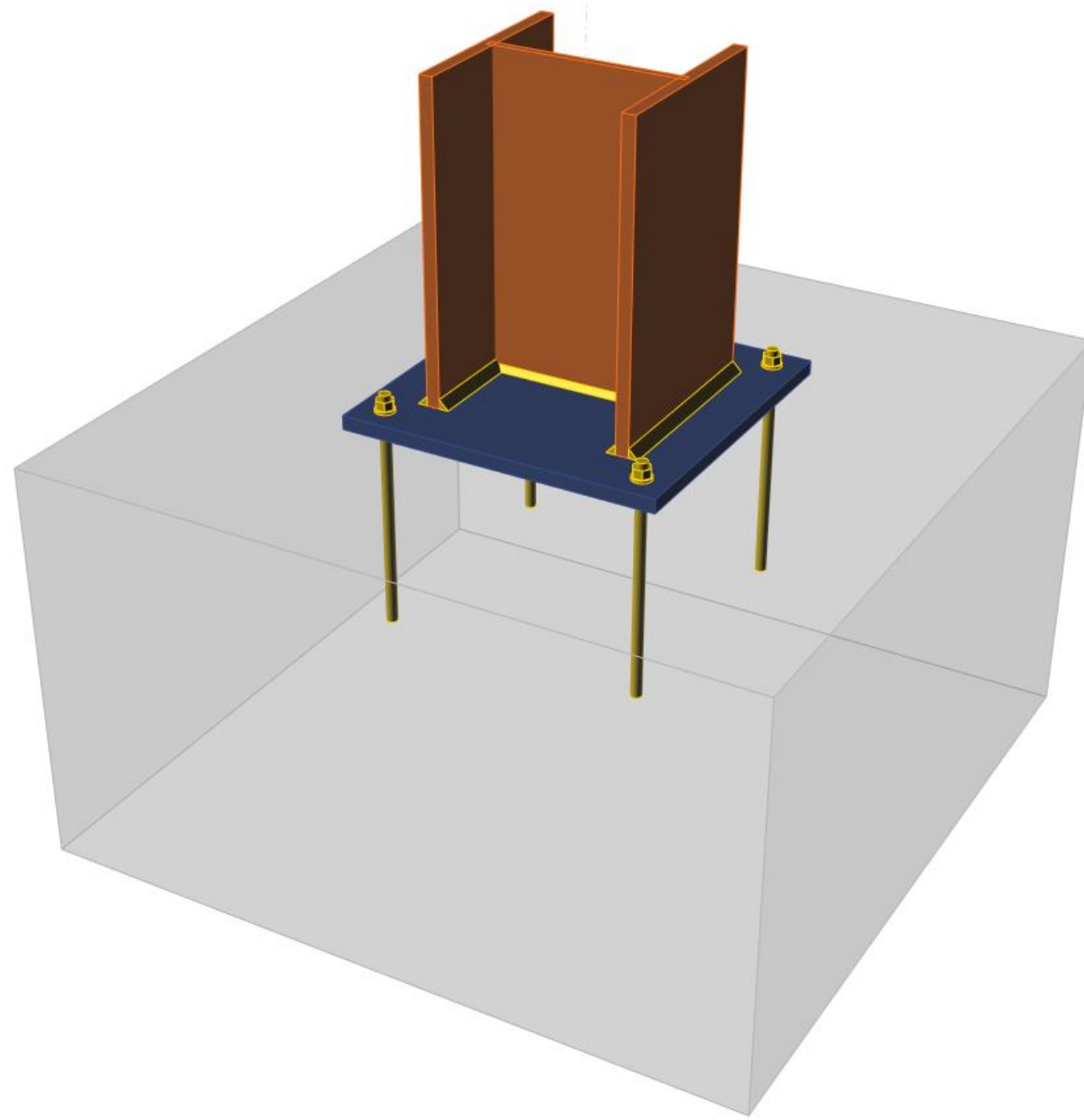


Shear: non-linear springs in contact with plate



- Anchor material properties are based on experimental Hilti research for the product assessments.
- The anchor stiffness is a product specific characteristic which differs depending on the selected product.

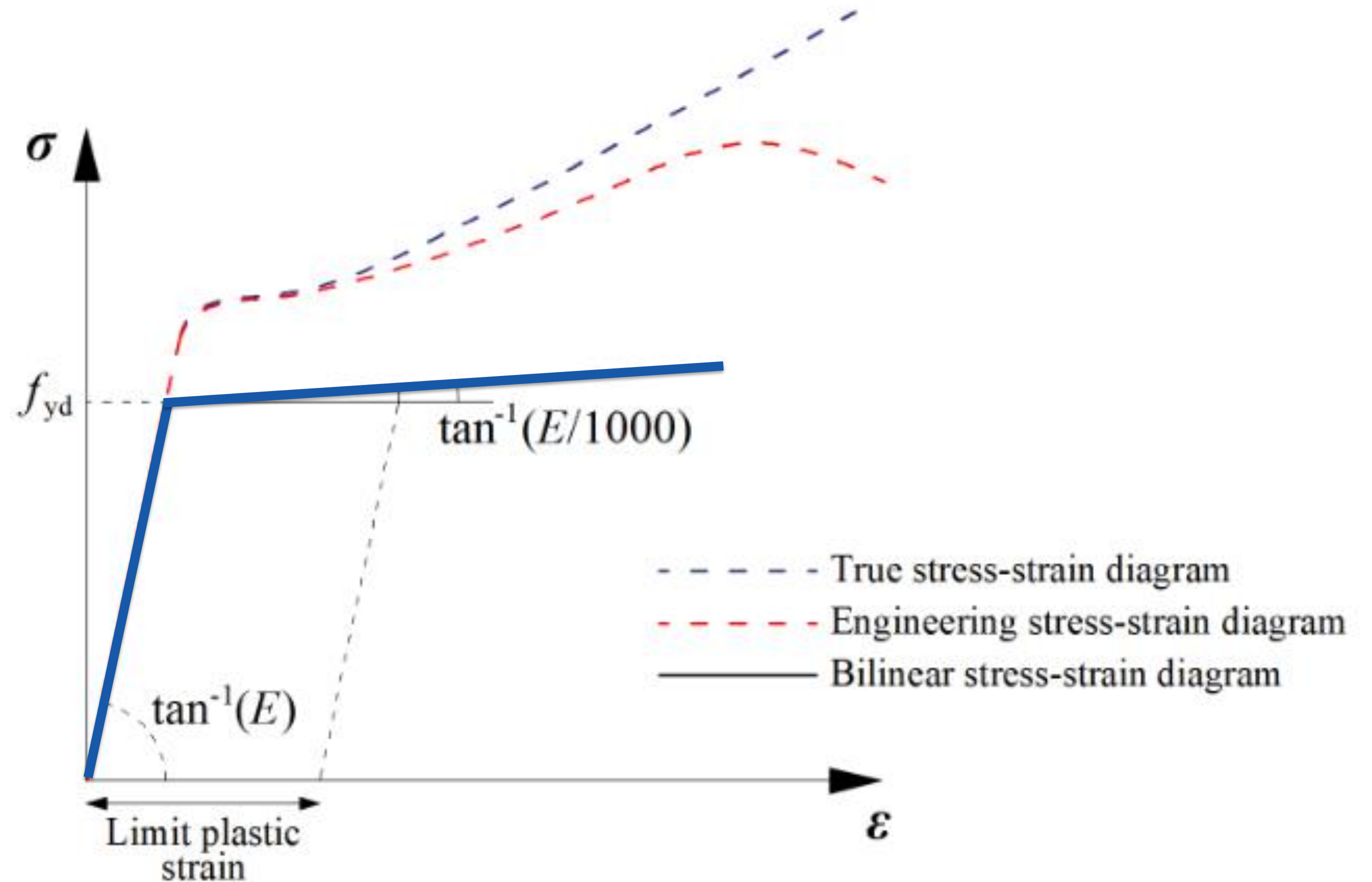
Concrete Block (CBFEM)



- Winkler-Pasternak foundation – represents deformation of a concrete block
- Compression is transferred via this subsoil

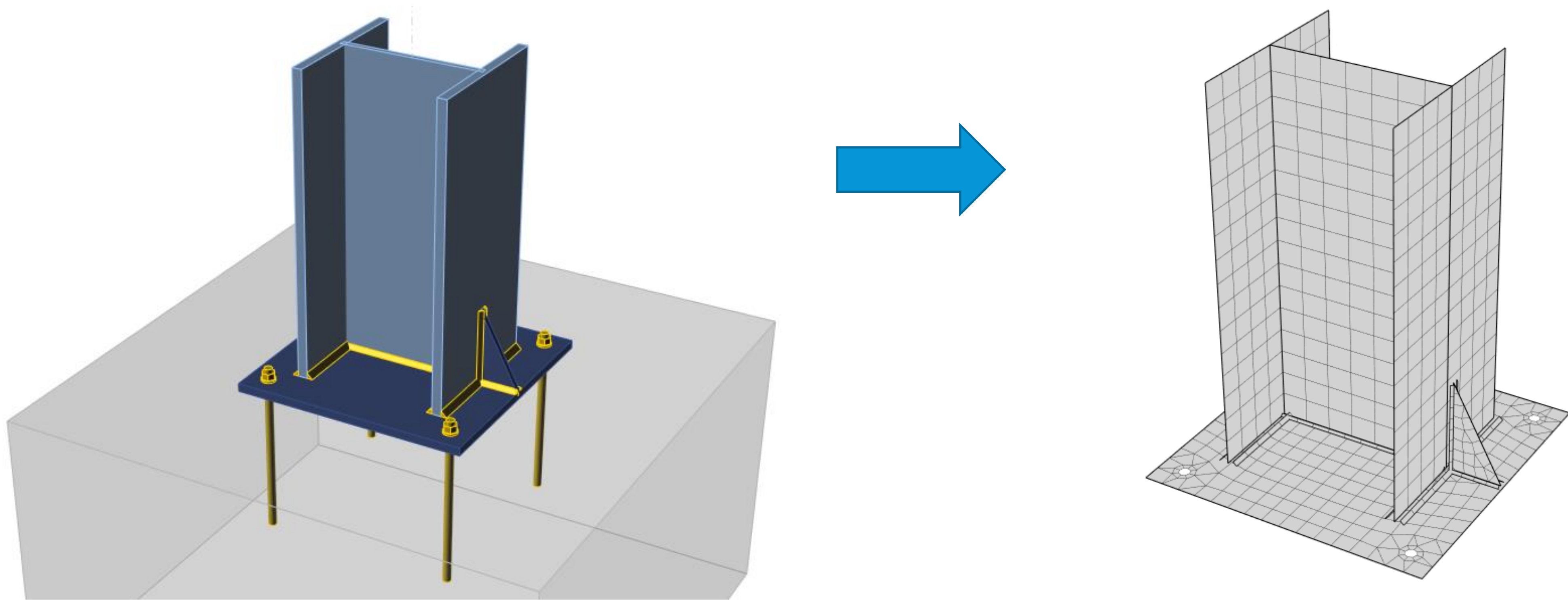
Modeling Steel Material Nonlinearly

- Material models of steel for research and design-oriented methods
- Check plates for limit of **equivalent plastic strain**

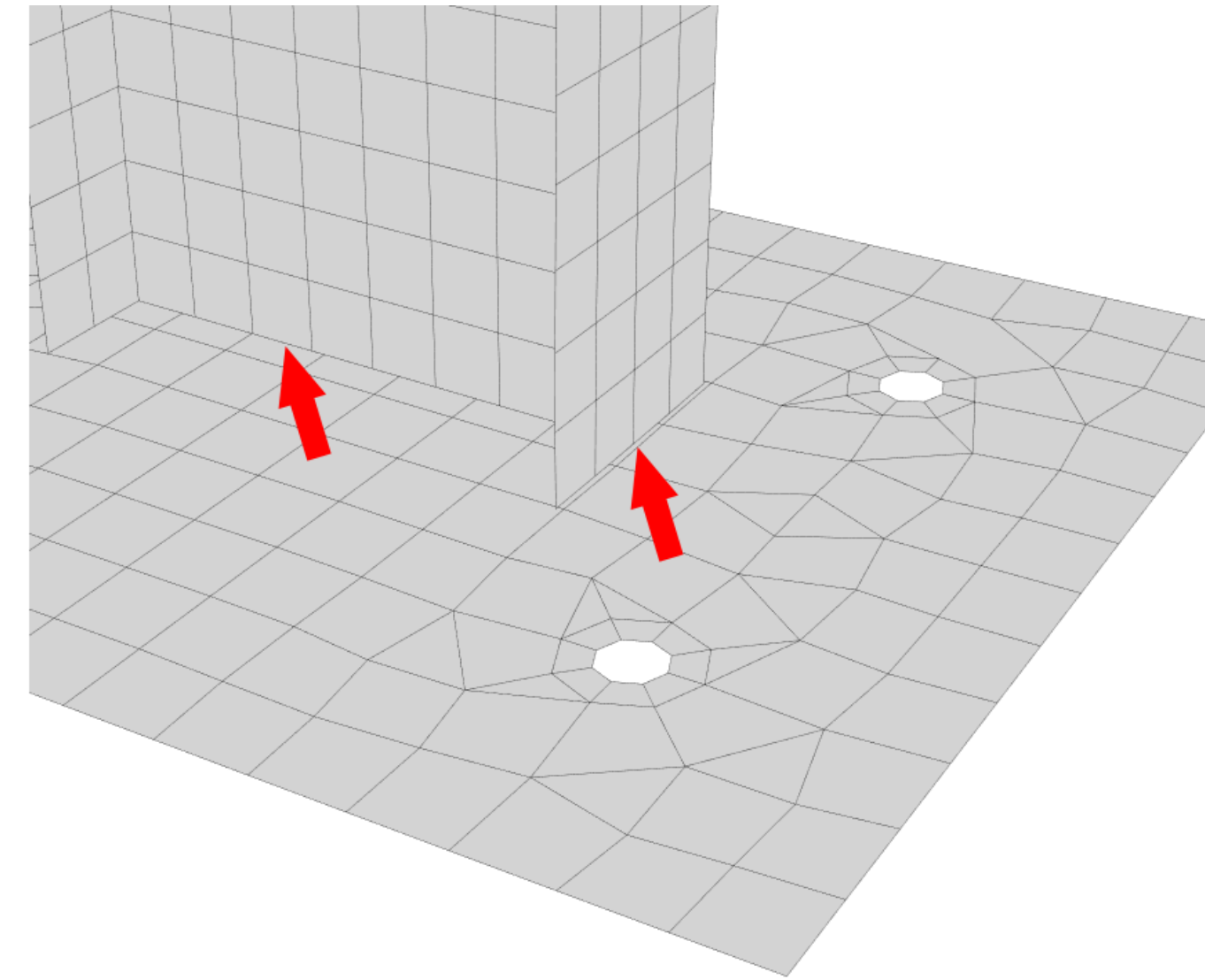
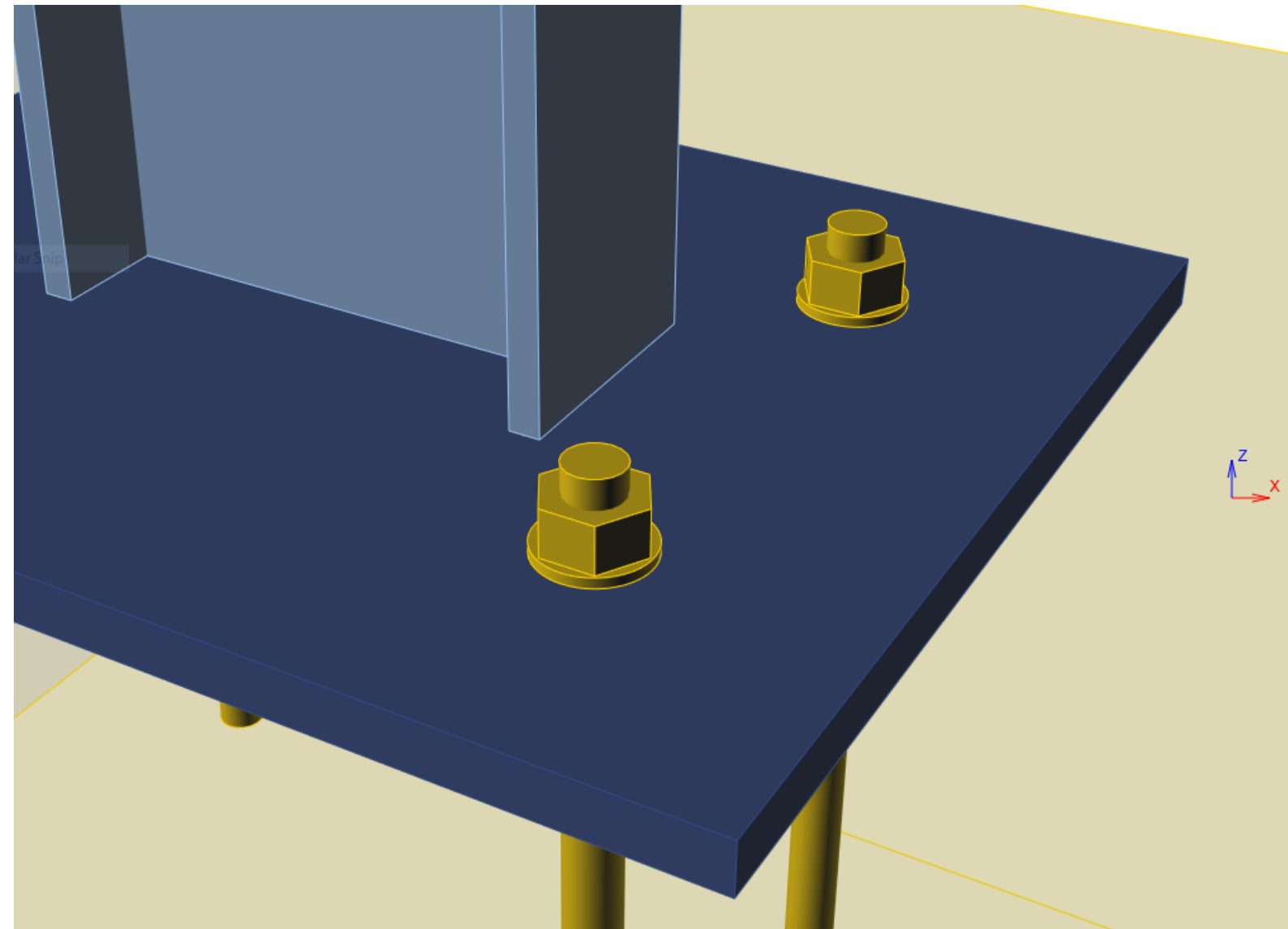


CBFEM Analysis Model

Automatic generation of the analysis model – no user input needed



Dedicated FEM Solver



- Majority of CAE/FEA programs have FEM solvers from early '90s
- Other industries moved faster – **aircraft industry**
- **Mesh** – no intersection between plates
- Plates are connected by **interpolation constraints and weld finite elements**
- **Calculation speed** (complex models solved in seconds)

Credibility and Verification of CBFEM

- Tailor-made design models created in various software (Midas FEA, Atena, Abaqus)
- Live testing
- All studies published
- Three years of studies produced by two university teams

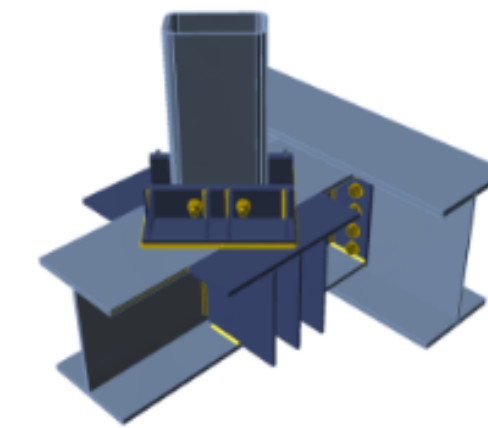
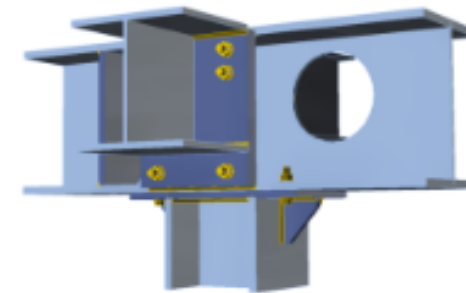
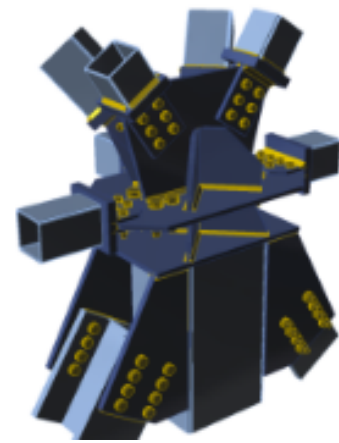
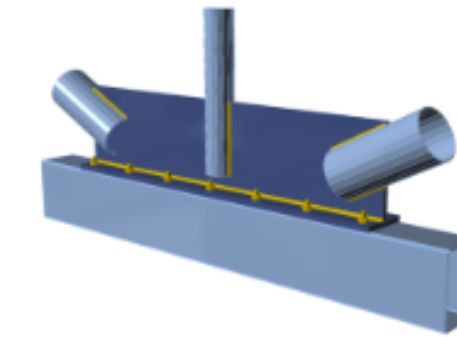
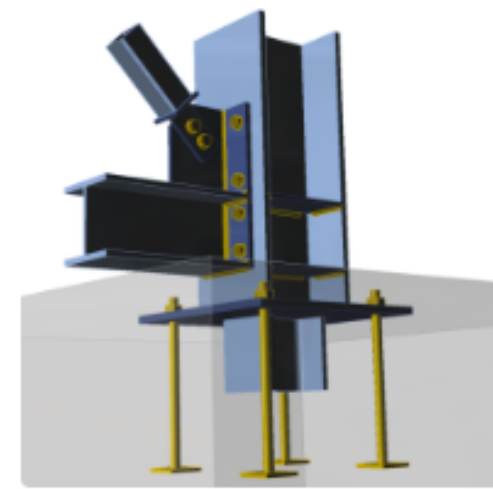
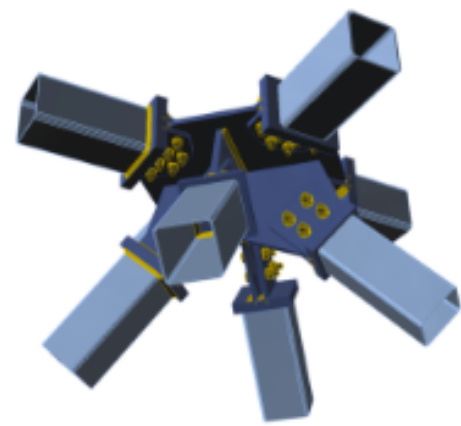


Cooperation with Universities = Verified Solution



What Makes CBFEM Unique?

- CBFEM method is robust and generally **without limits** in topology, design or structure loading.



CBFEM powers multiple SW tools:

- IDEA StatiCa



- Advance Design Connection



- HILTI PROFIS Engineering

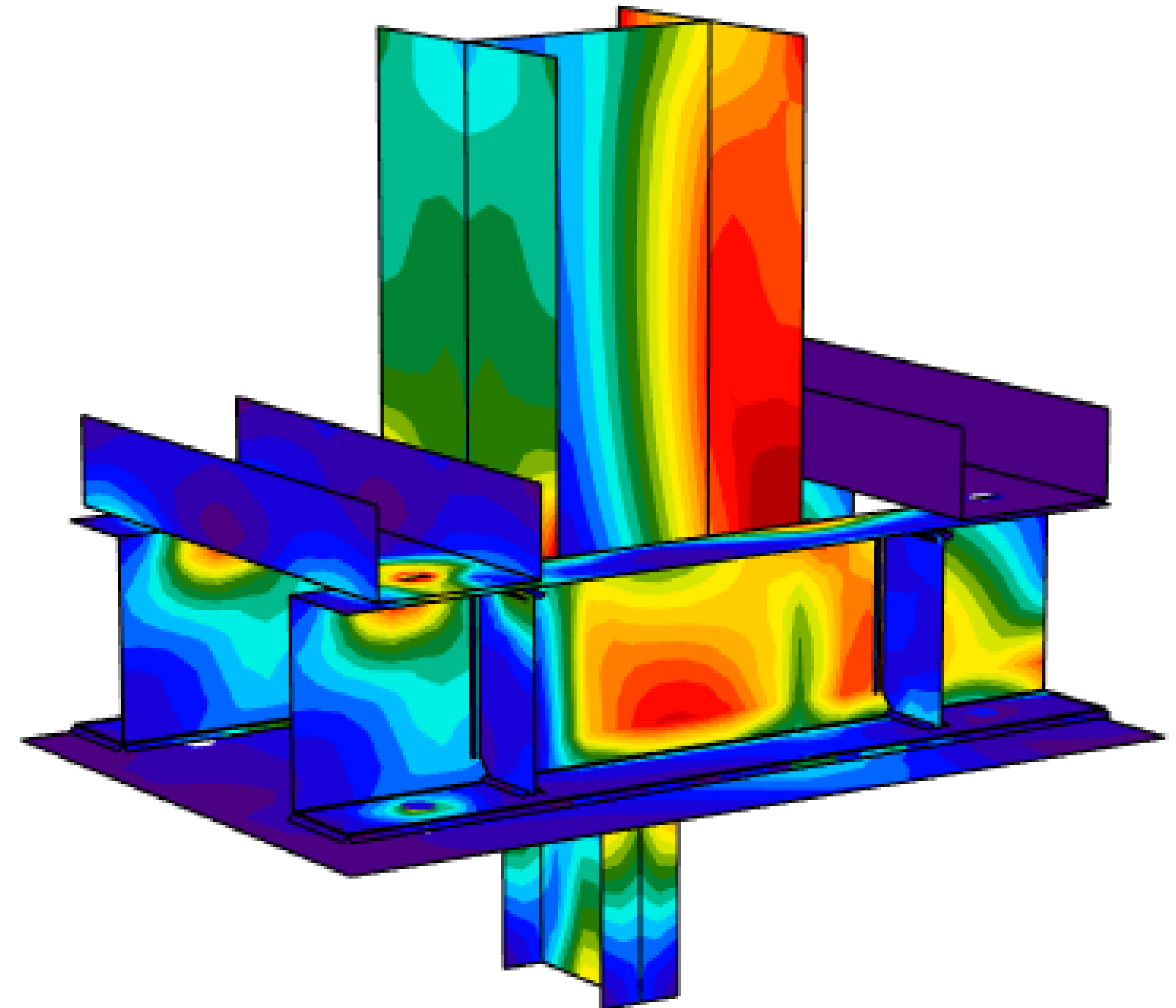
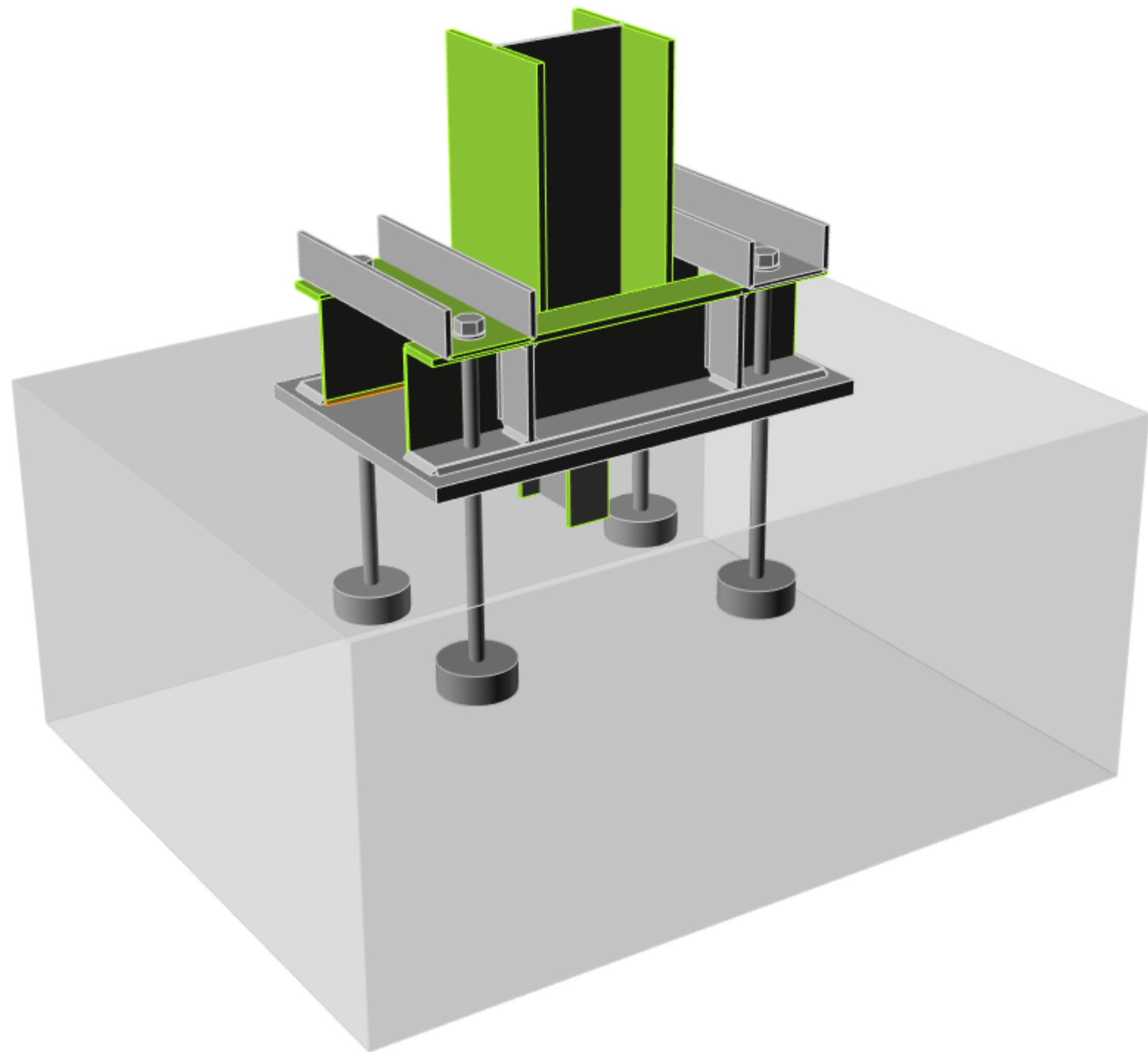


- Voestalpine Profilform



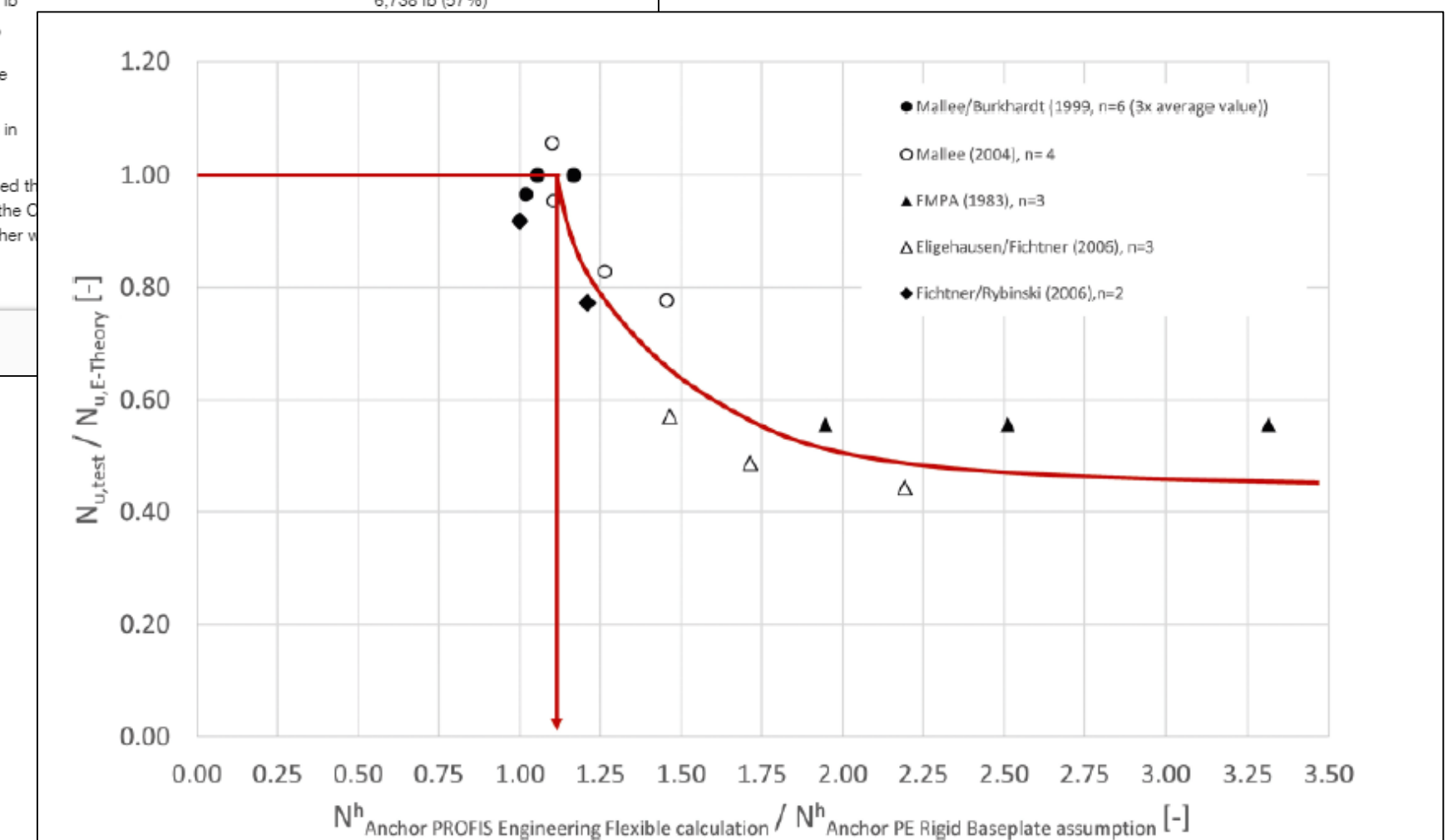
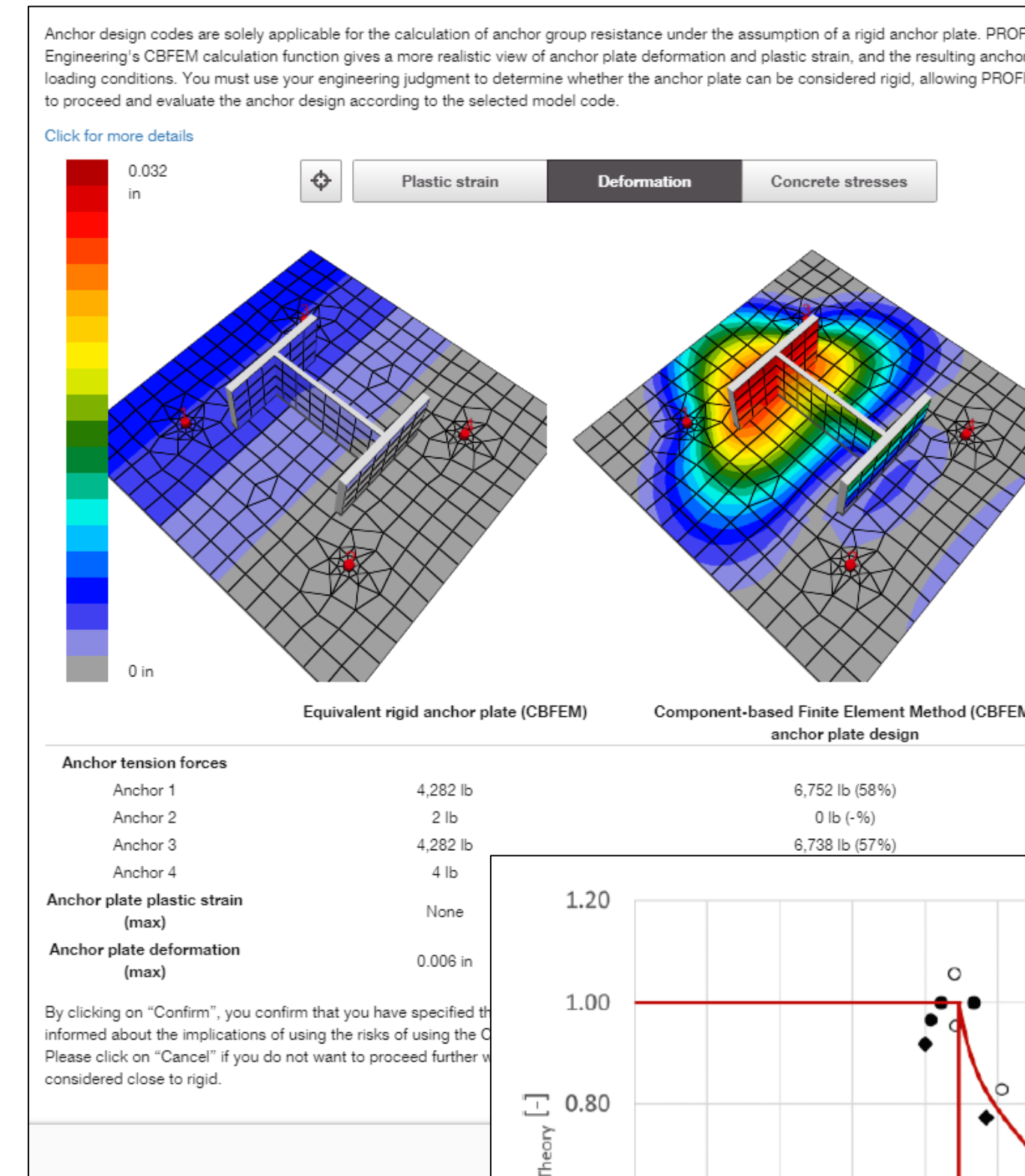
Where can I learn everything about **CBFEM**?

www.cbfem.com



CBFEM helps you to meet ACI code requirement of rigid base plate

- Select the base plate you would like to have
- Software will compare “theoretical” rigid base plate and “flexible” CBFEM results for each case and show the deviation for your case compared to the rigid base plate
- Publication gives guidance which deviation can be accepted
- Engineering judgement can also be applied to finally validate your base plate can be considered rigid and ACI requirement is met
- **Full article available in the class material**



Applying Advanced Analysis

A multifaceted background in structural engineering led to an open-minded approach to design and pushing boundaries.

- BS Civil Engineering, UCLA
- MS Structural Engineering, Stanford University
- Engineer at Degenkolb in SF
 - Analysis standardization – focus on nonlinear analysis
 - Embrace new advanced/cutting edge design approaches

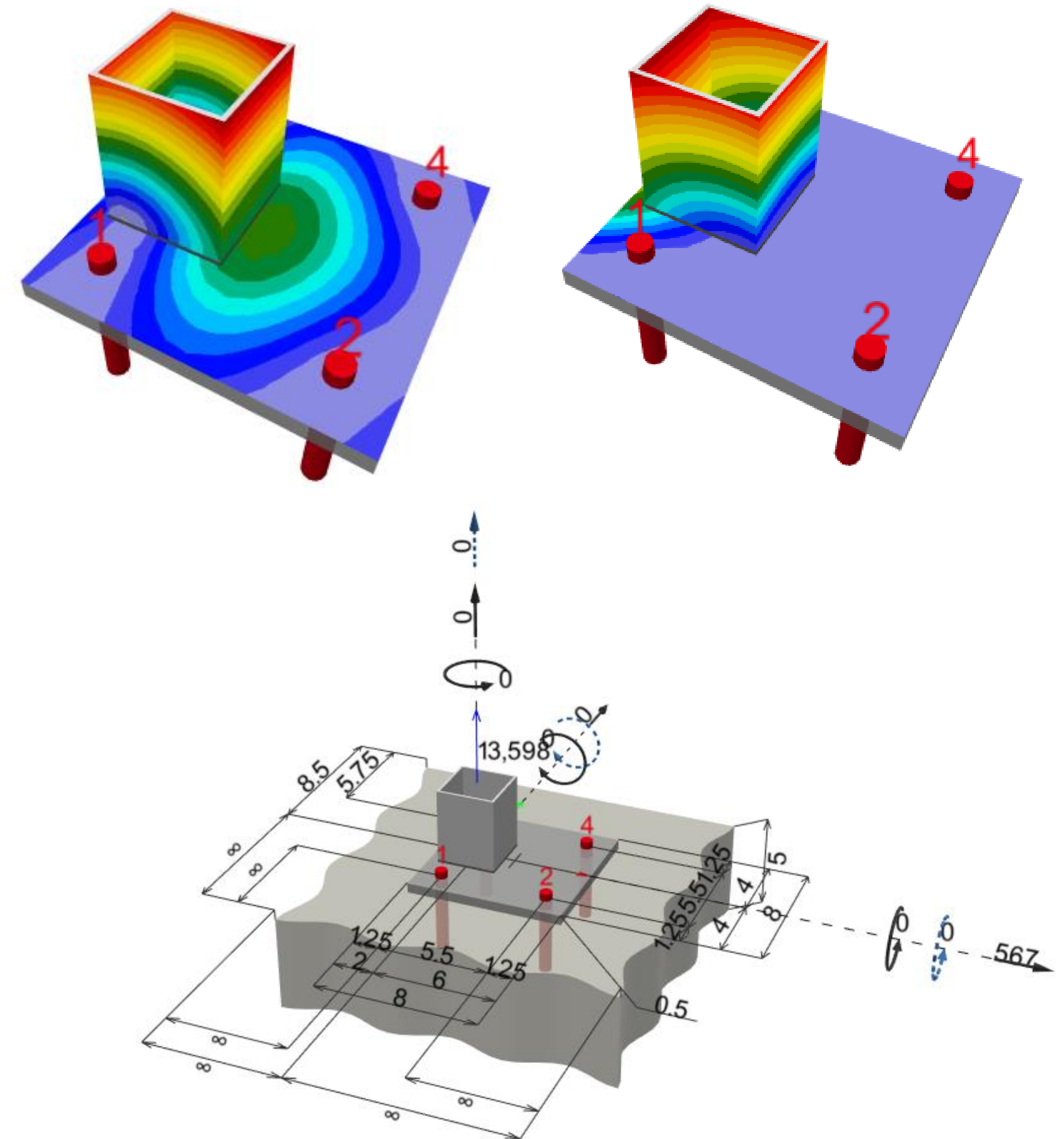
Let's dive into a real application of CBFEM to solve challenging design problems: A retrofit and tenant improvement for new corporate office in Bay Area.

- 4 story concrete moment-frame building
- Large floor openings with LED Guardrail Display
- Precast, Post Tensioned Gravity Beams
- Add 19 viscous fluid dampers

Eccentric Guardrail Post

Interior connection of guardrail on top of slab with large eccentricity in order to hide base plate behind rail

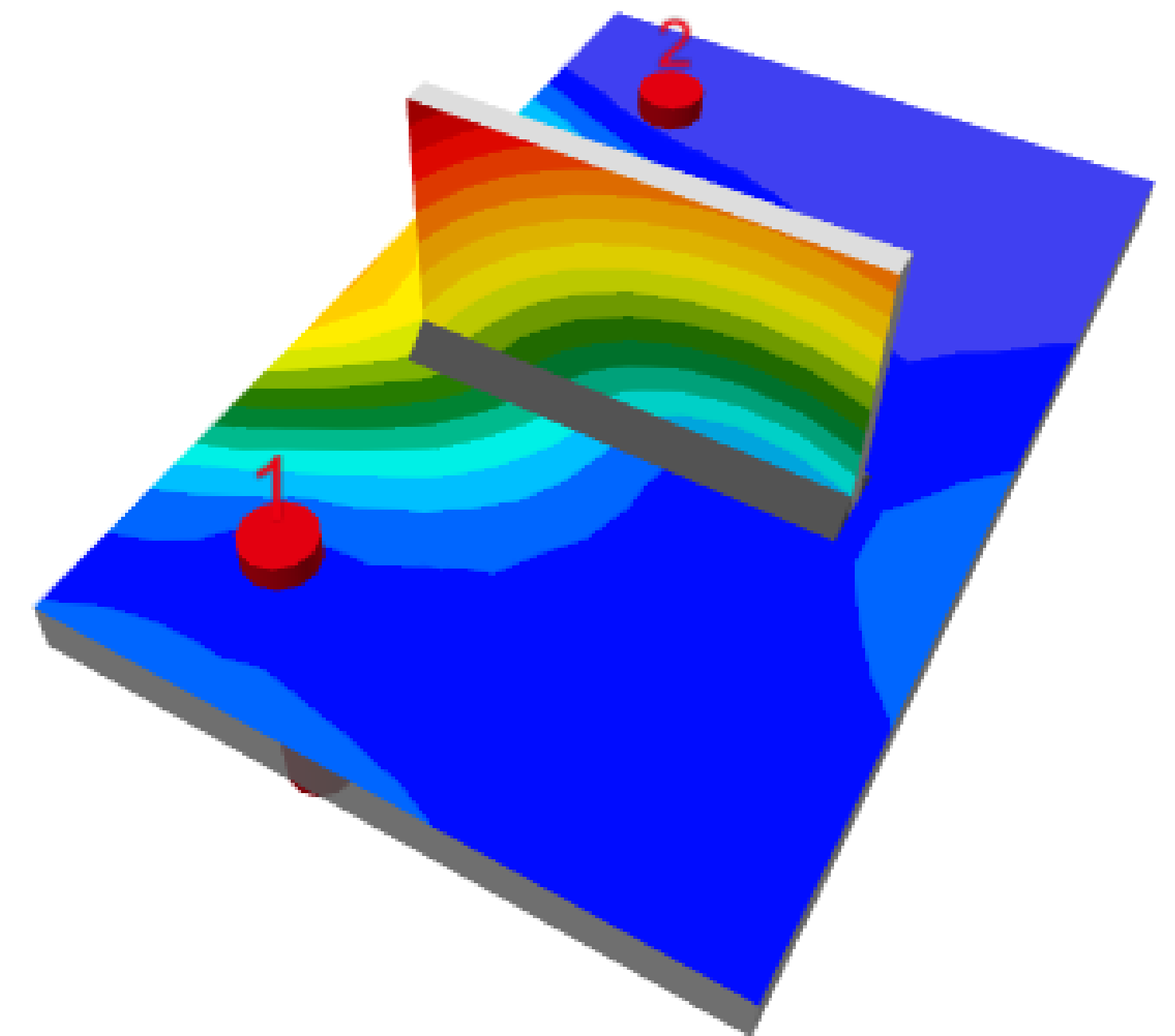
- Non-standard application with large eccentricity
- PROFIS Engineering CBFEM summary provided small resulting deformation
- Greater confidence in connection design by using more realistic design forces



Avoiding PT Tendons

Pre-cast post-tensioned concrete that required steel beam connection restricted to two post-installed anchors

- Contractor requested special connection to avoid hitting PT tendons during drilling
- Large eccentricity from intersection with I-beam profile
- Required a more sophisticated model to verify more complex geometry



Damper to Moment-Frame

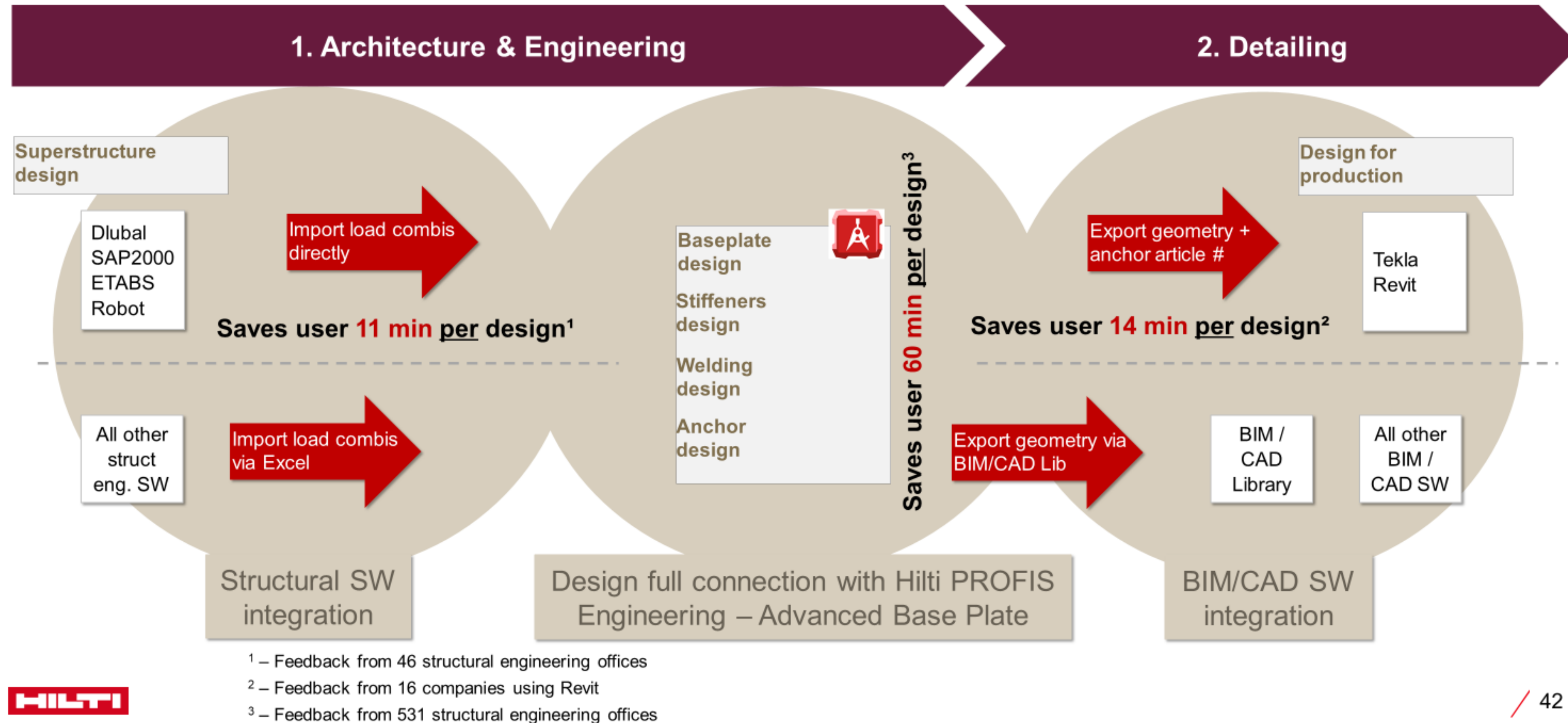
76 individual damper connections, each with unique anchor layout and extremely large forces

- Non-uniform spacing of post-installed anchors due to reinforcement congestion
- Required detailed software to model analyze multiple iterations of unique anchor layouts



How will you apply CBFEM?

Hilti and CBFEM are making streamlined workflow a reality

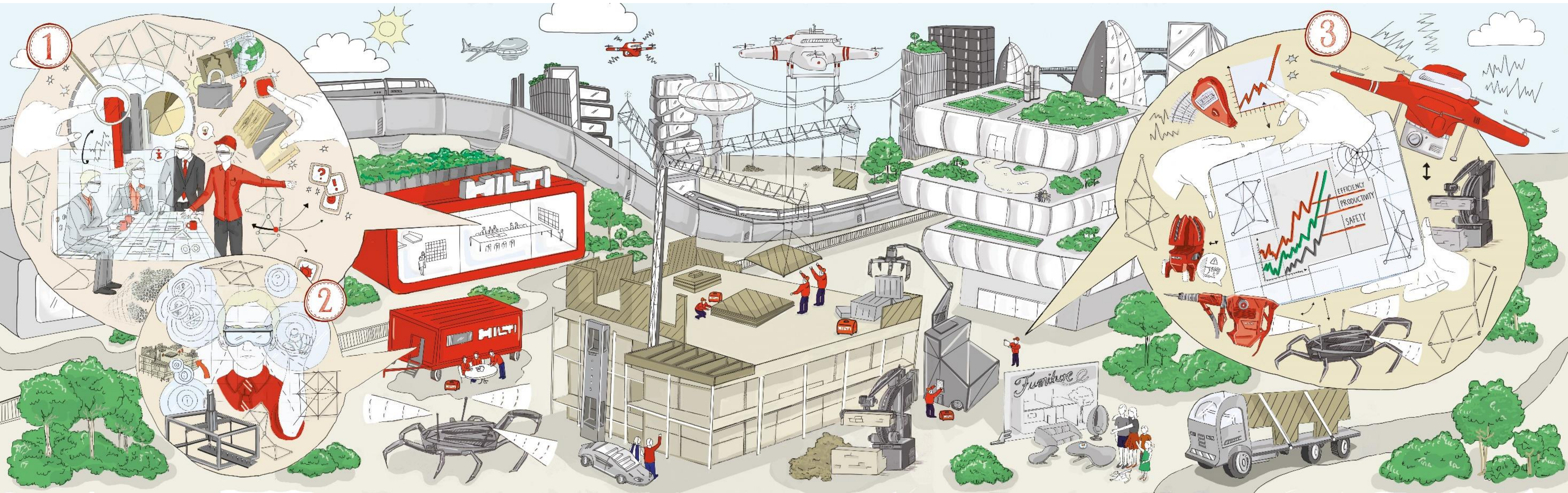


Want to start saving >1 hour per connection? Free 30-day trial available [here](#)

Questions?

**Please also visit the Hilti
booth CON372 to get your
personal demo!**

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