DIANA 10
Integrated Environment
Staalbouwdag Ab van den Bos



Civil Engineering
Geotechnical Engineering
Petroleum Engineering

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Introduction of a new TNO DIANA service

- TNO DIANA *Engineering* began in April 2014
  - to help users with their own projects.
    - when time is critical and human resources are sensitive to planning schemes.
    - when ‘know how’ or workflow for a new topic has not yet been standardised.
  - different levels of aid include;
    - Setting up models
    - Carrying out analysis
    - Reporting

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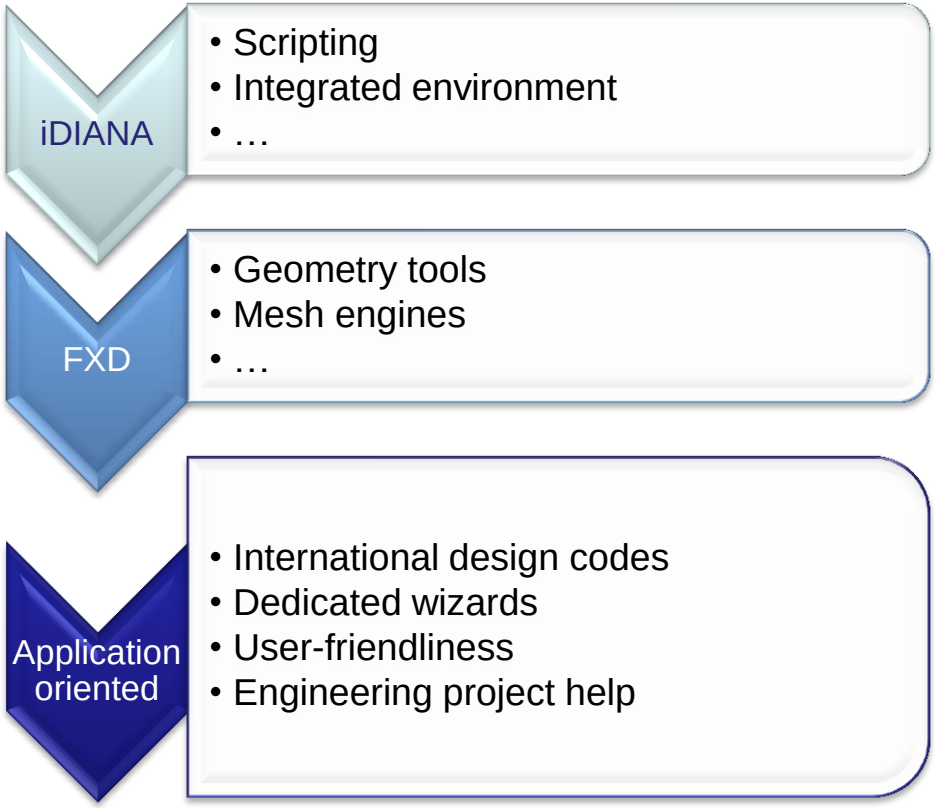
Background and development direction



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resulting in a new integrated environment

A friendly face to finite elements;

- Allows creative designs in a friendly environment
- Scripting for the definition of repetitive jobs
- Parameterisation reduces duplication and enhances productivity
- Powerful parallel processing reduces run times and your wait times
- Comprehensive material models allow high order analysis
- Soil structure interaction
- Fluid structure interaction
- Comprehensive seismic analysis options

Features from Civil Engineers for Civil Engineers

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Steel connections - earthquake loading

Ballio, Mazzolani - Strutture In Acciaio

- Material ductility
- Joint ductility (redistribution)
- Global structural ductility

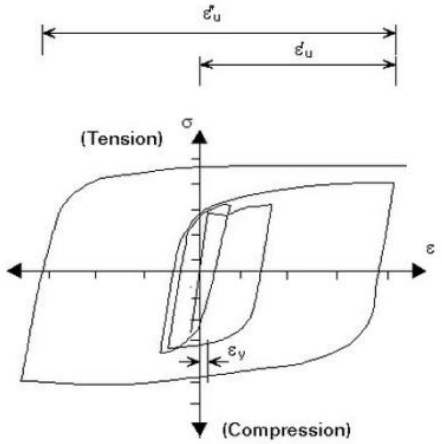

Figure 1 Stress-strain relationship of a structural steel under uniaxial hysteretic loops

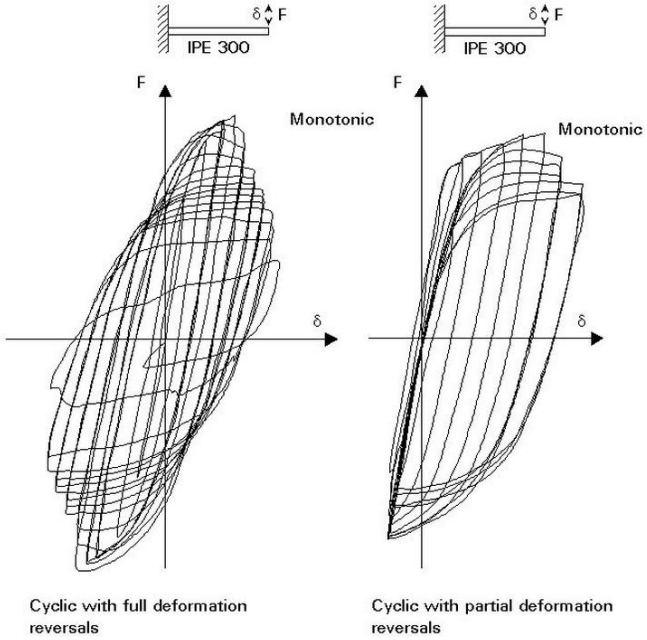

Figure 3 Influence of loading history on the cyclic behaviour of beams

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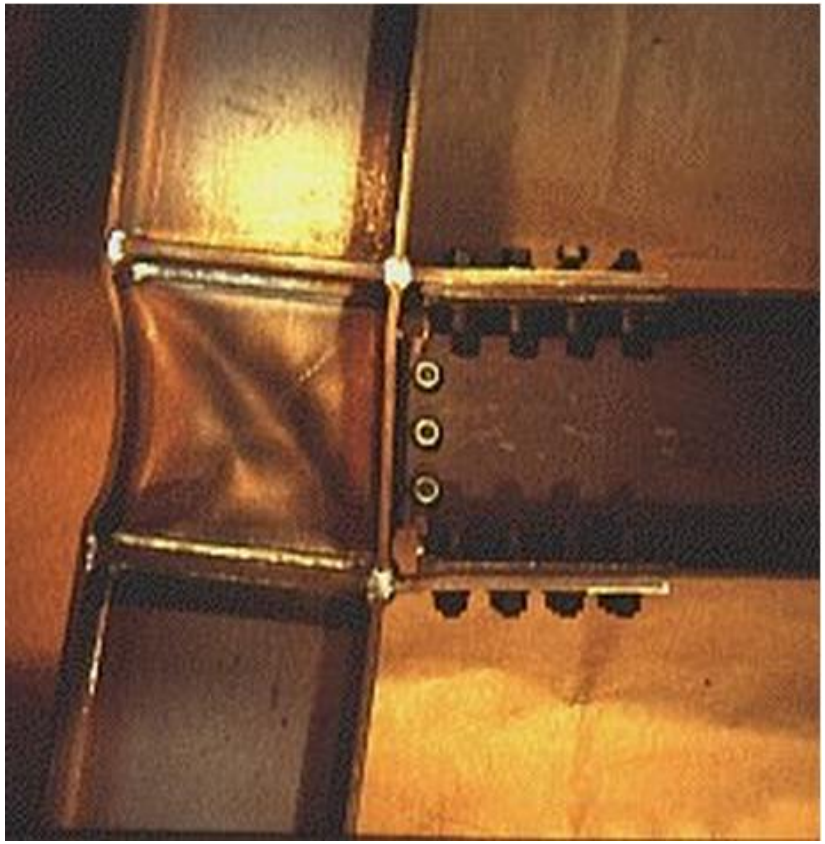
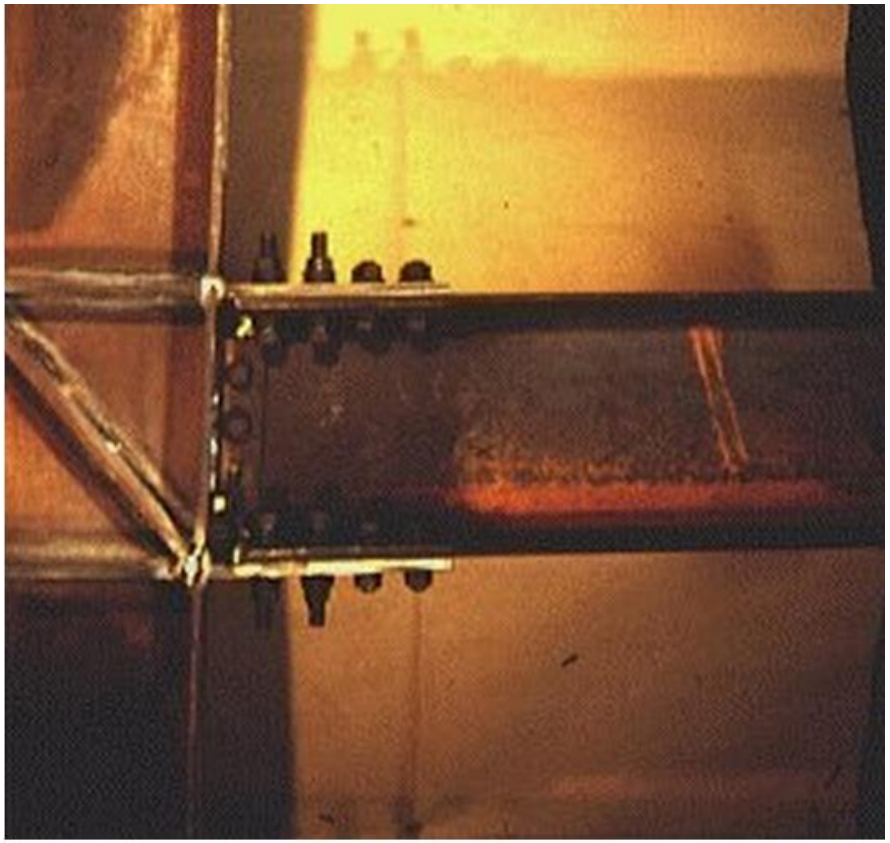
Steel connections - earthquake loading





$R_d \geq 1{,}20\ R_{fy}$ in other words : connection ≥ adjacent element

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Steel connections - earthquake loading

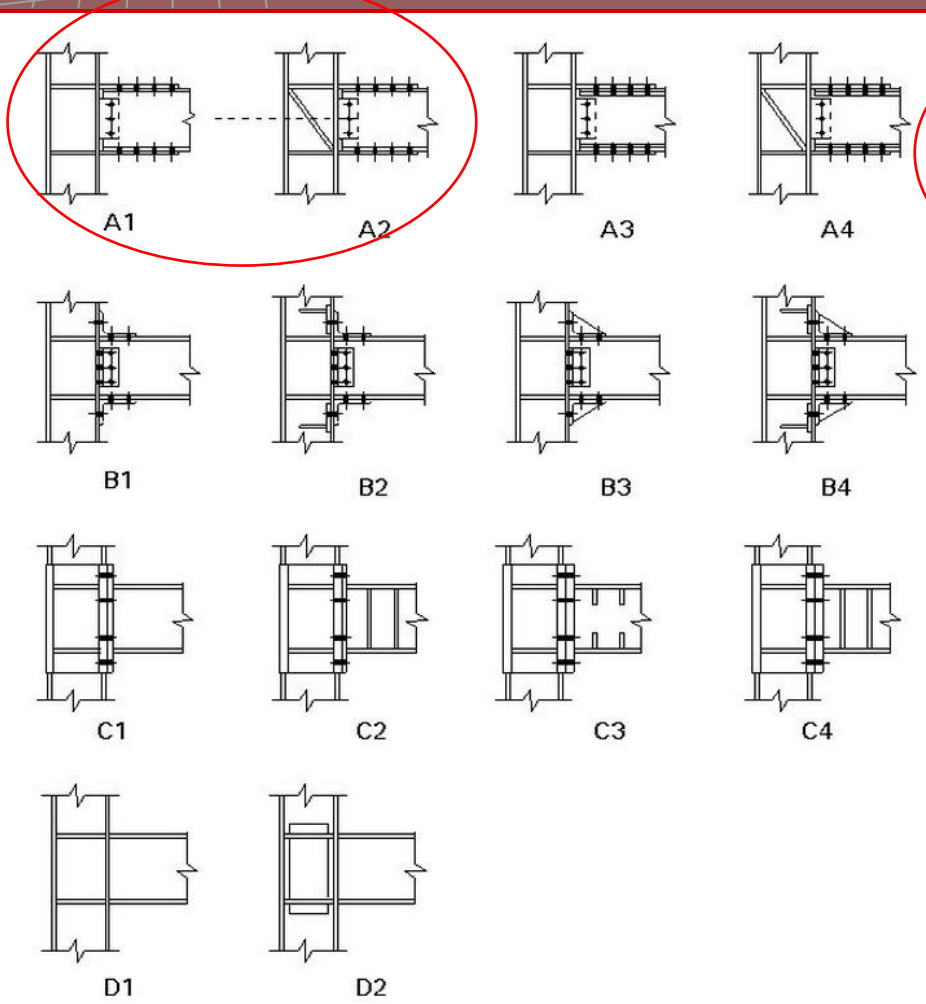

Figure 11 Types of beam-to-column connections tested by Ballio, Mazzolani et al.

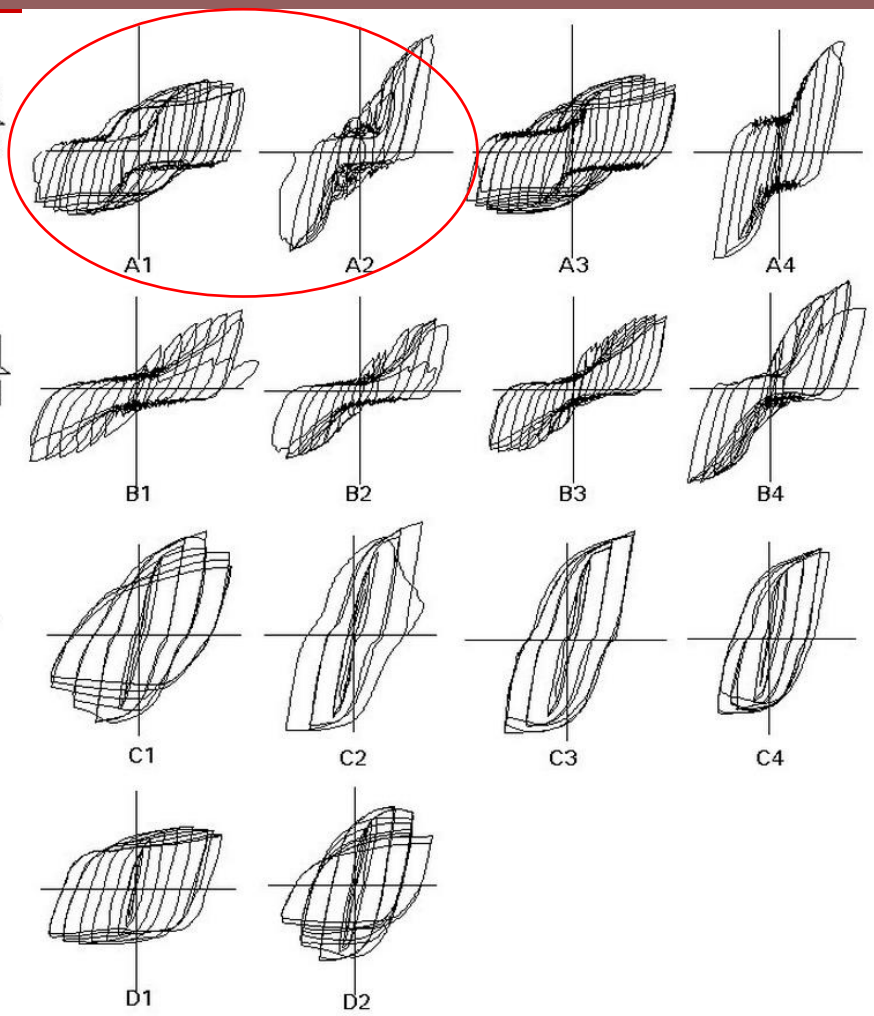

Figure 12 Hysteresis loops of beam-to-column connections tested by Ballio, Mazzolani et al.

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Steel connections - earthquake loading

Modified Two-Surface Model

Shen, Mizuno and Usami

– **Cyclic behavior including yield plateau**

- Yield inner surface
- Bounding outer surface

– **Extended to 3D**

Figure 19.22: Uniaxial cyclic stress-plastic strain curve

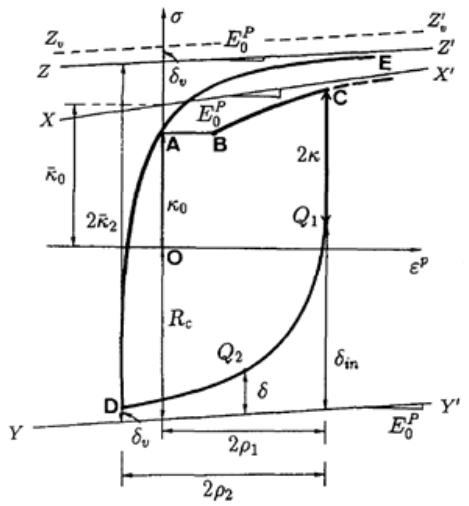
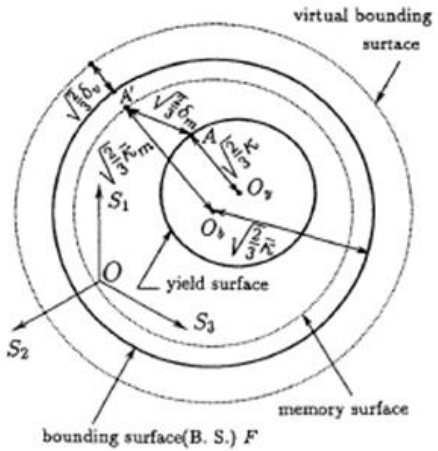


Figure 19.25: Virtual bounding surface and memory surface



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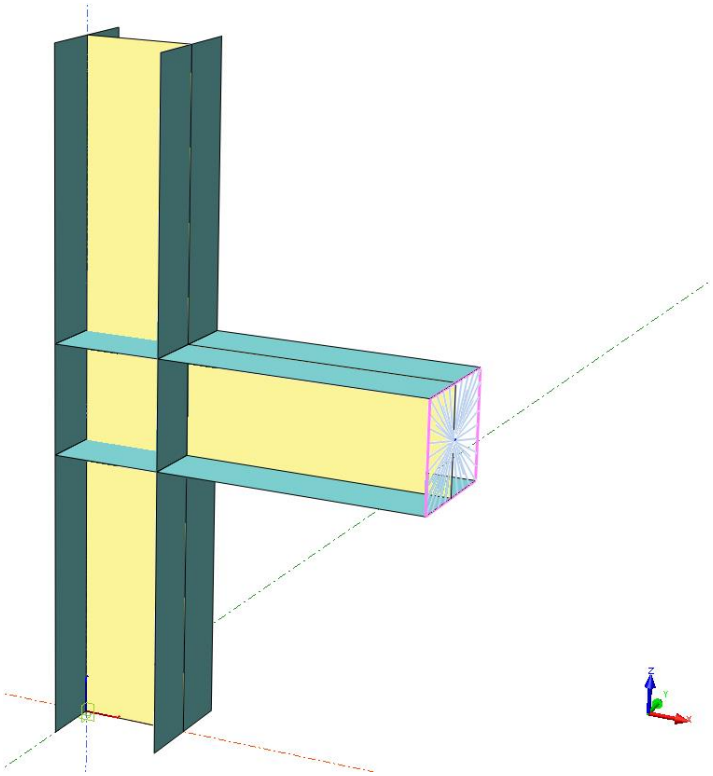
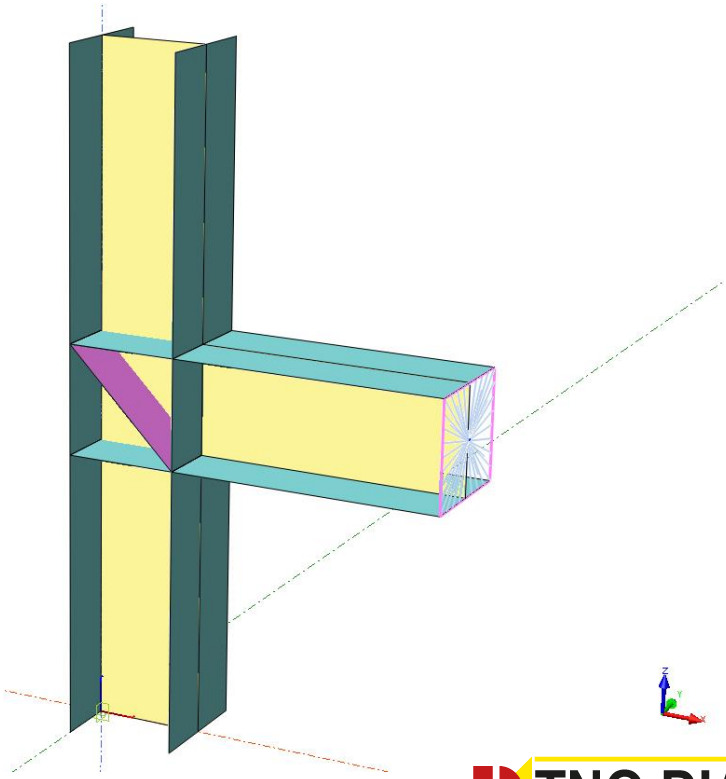
Steel connections - earthquake loading

Standard profile:HEA180

Additional stiffener (purple): t=6 mm





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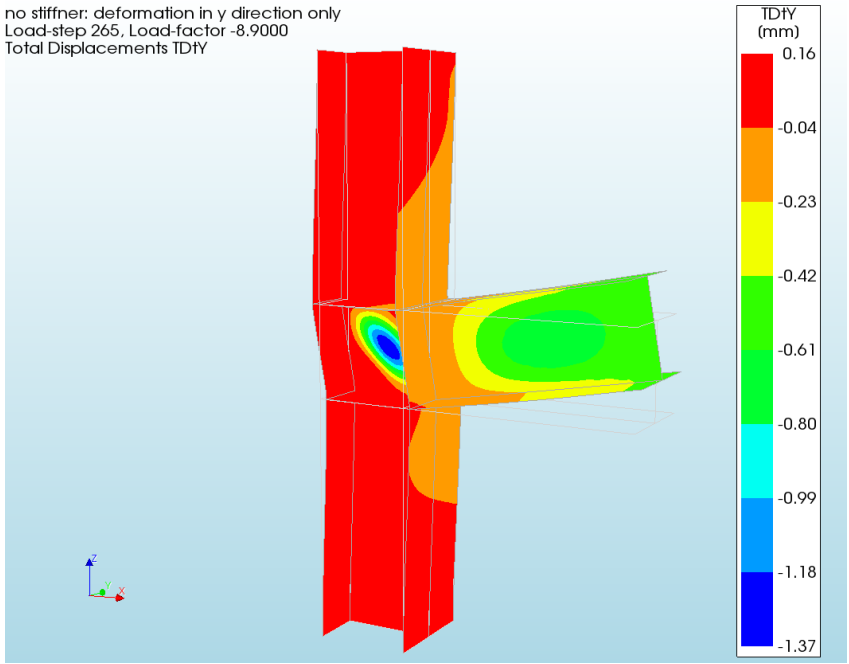
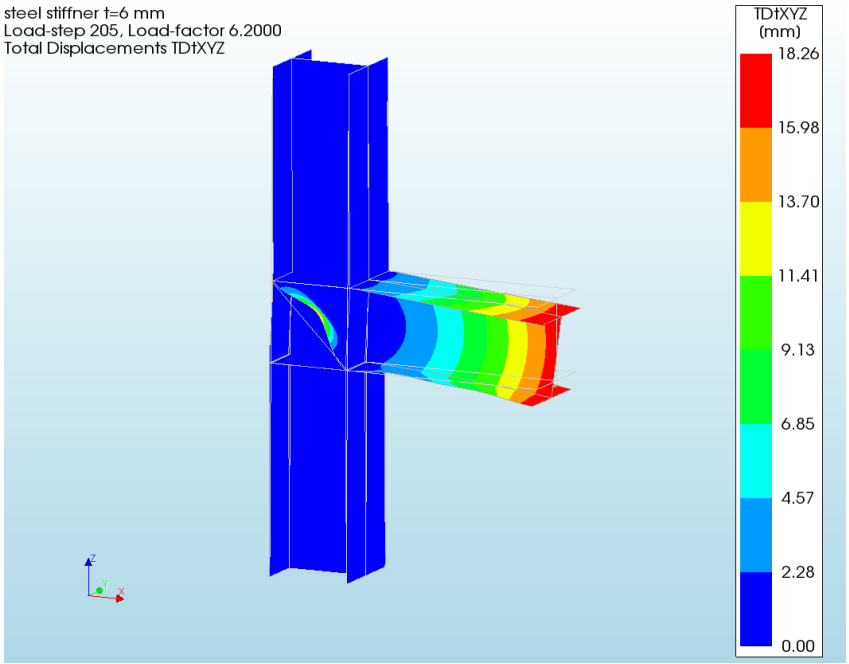
Steel connections - earthquake loading





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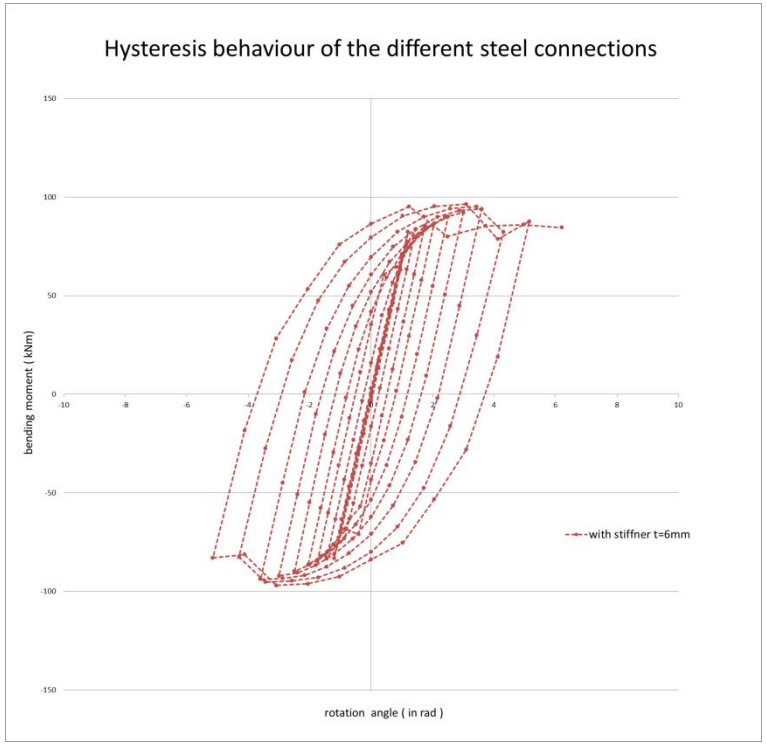
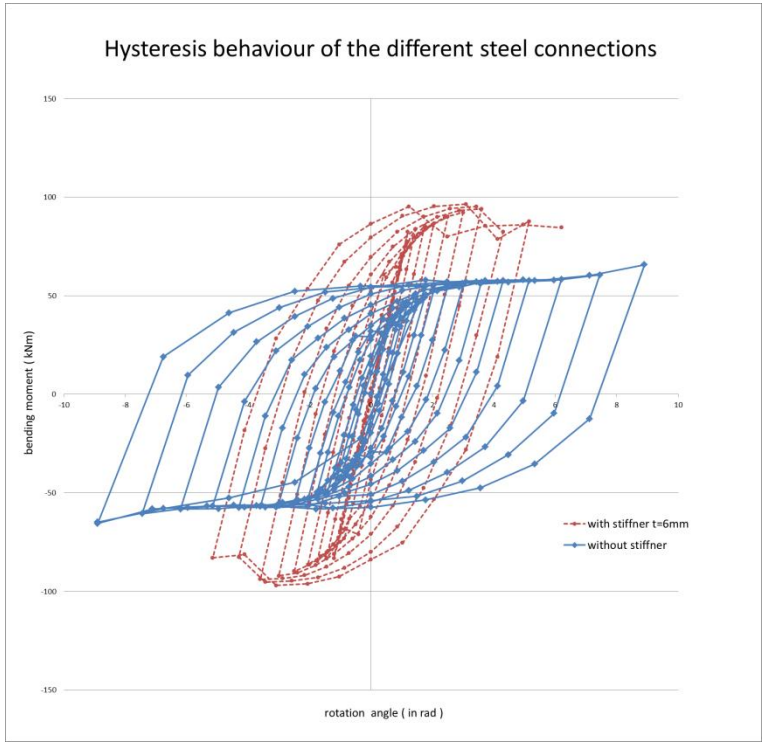
Steel connections - earthquake loading





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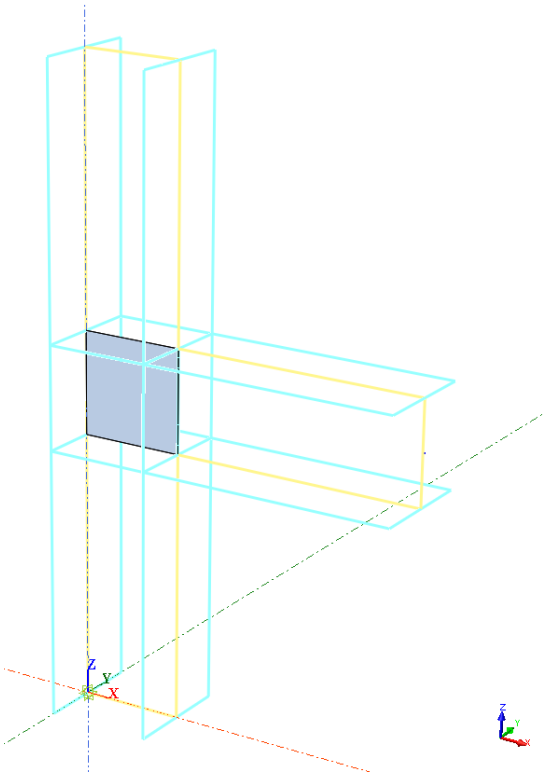
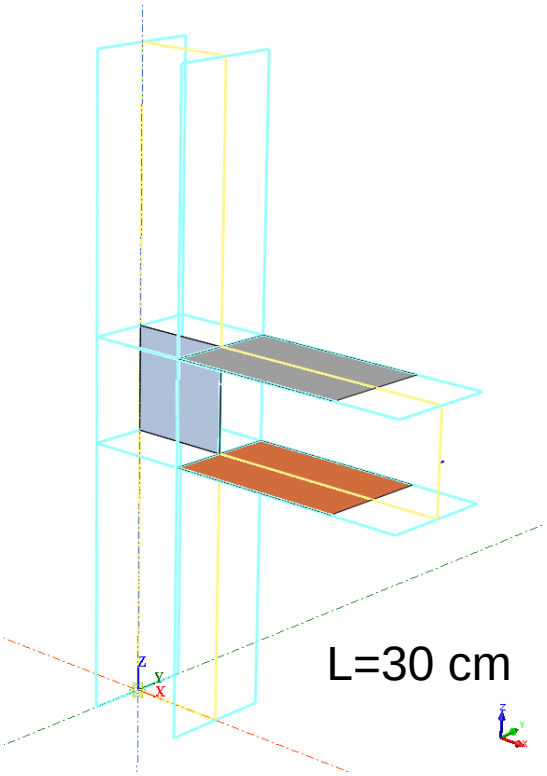
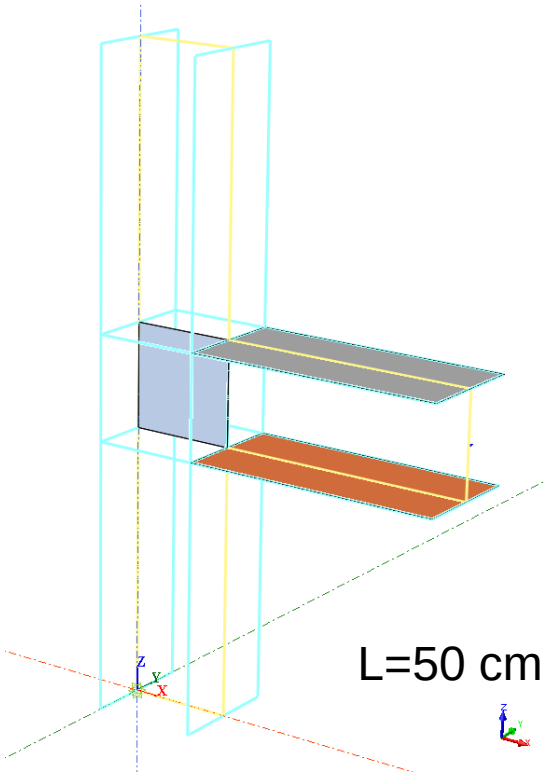
Steel connections earthquake loading

Composite layer: t=5mm, variant solutions







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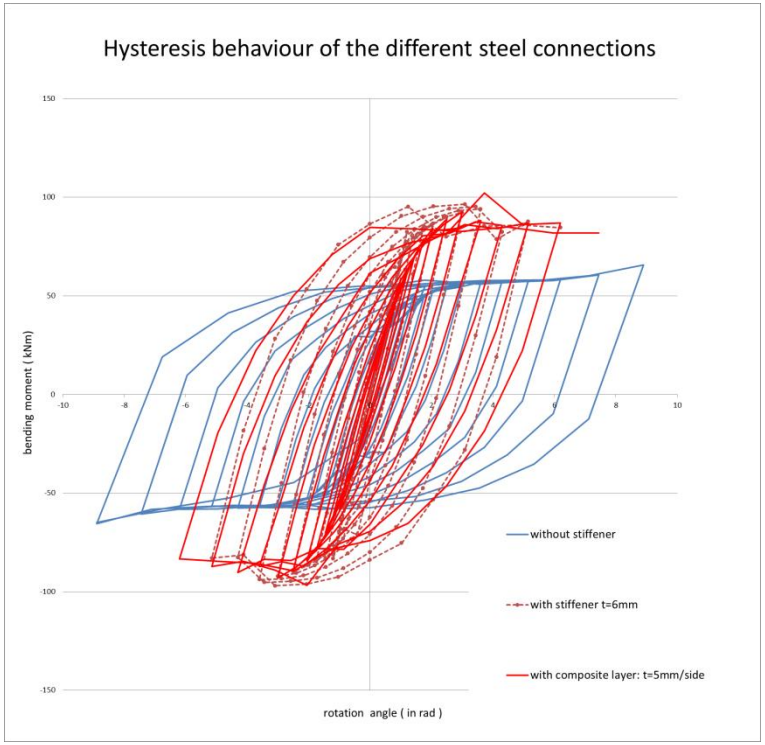
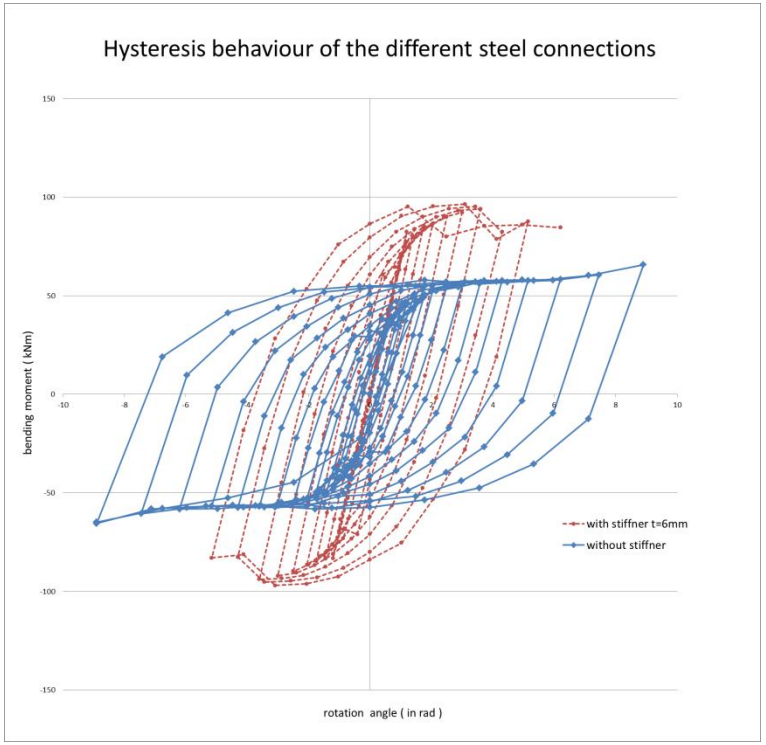
Steel connections earthquake loading

Only 5 mm in the section joint





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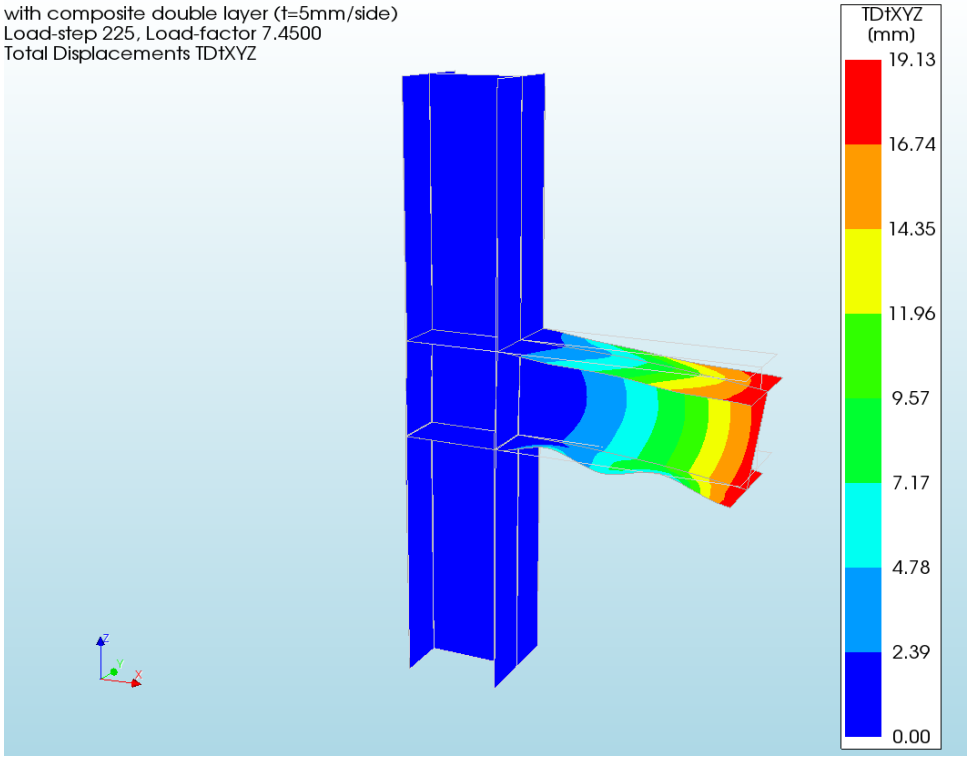
Steel connections earthquake loading

Only 5 mm in the section joint



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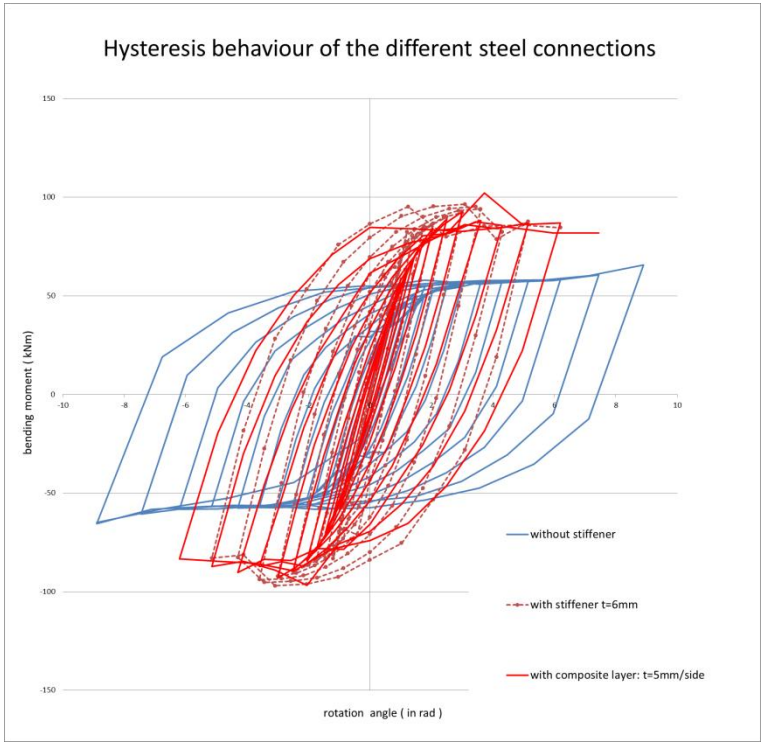
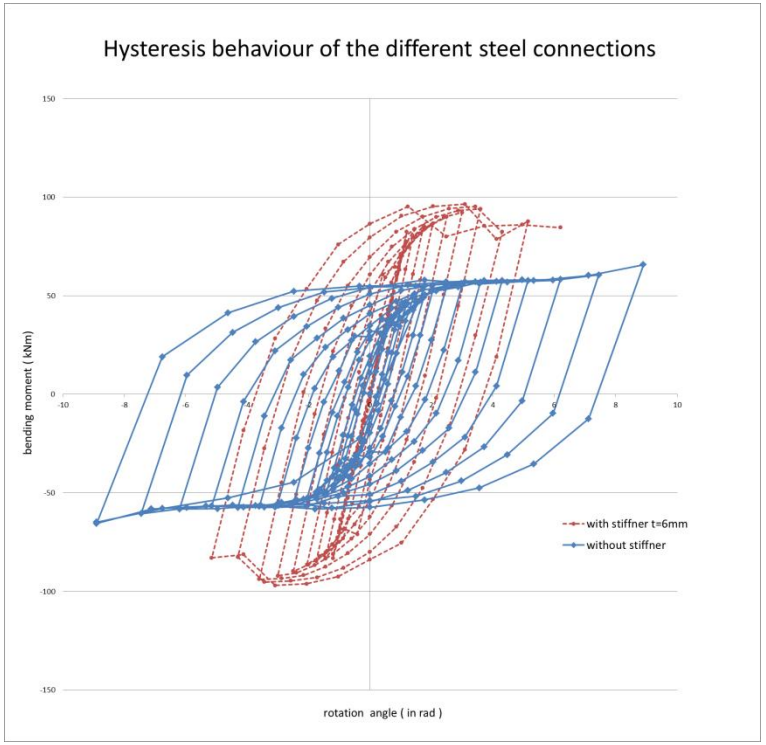
Steel connections earthquake loading

Only 5 mm in the section joint





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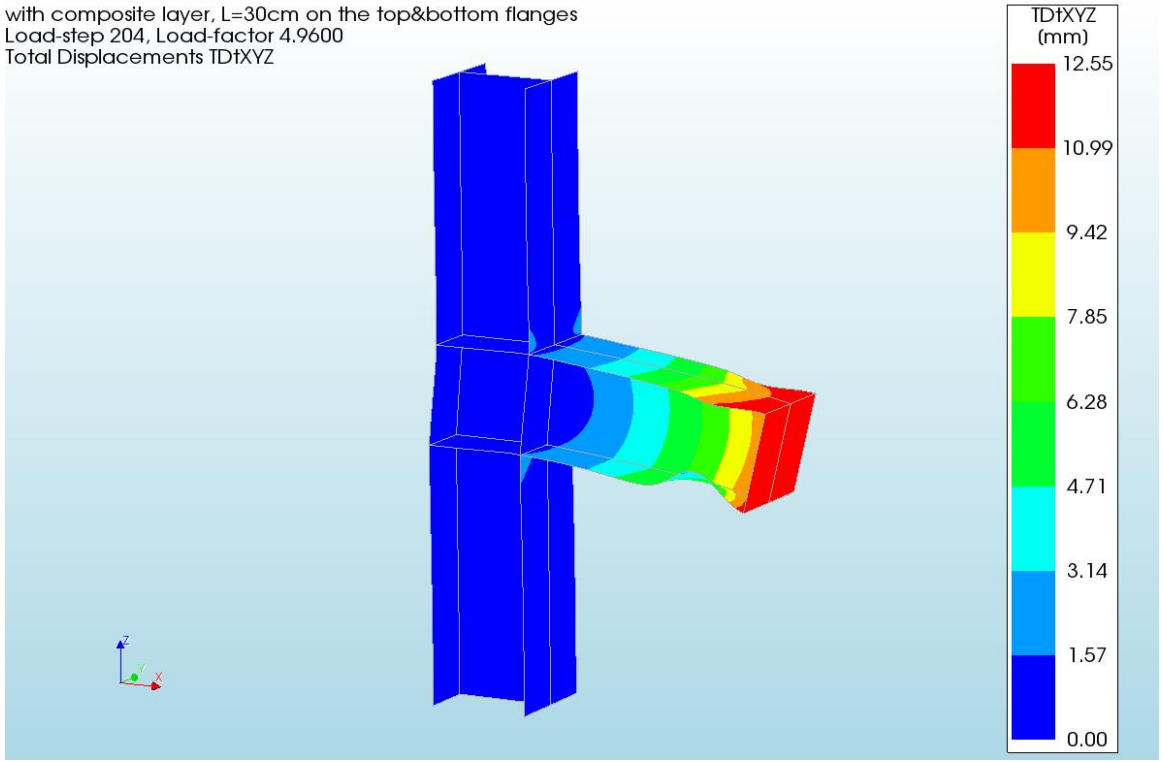
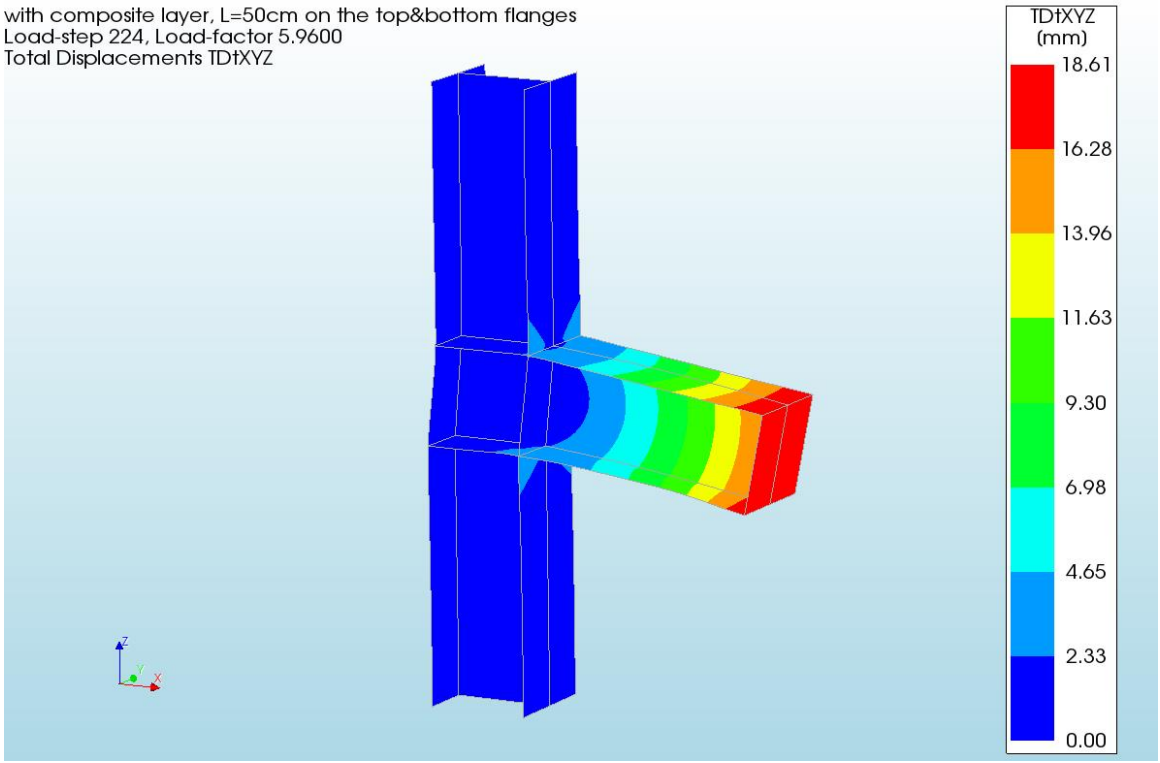
Steel connections earthquake loading

With extra layers on the top&bottom flanges, L=30 cm



Steel connections earthquake loading

With extra layers on the top&bottom flanges, L=50 cm



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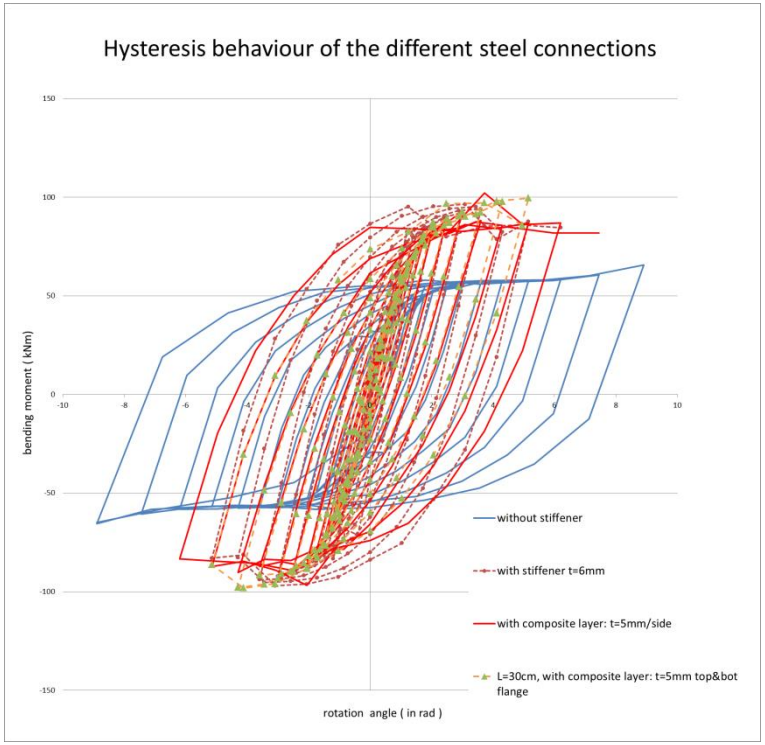
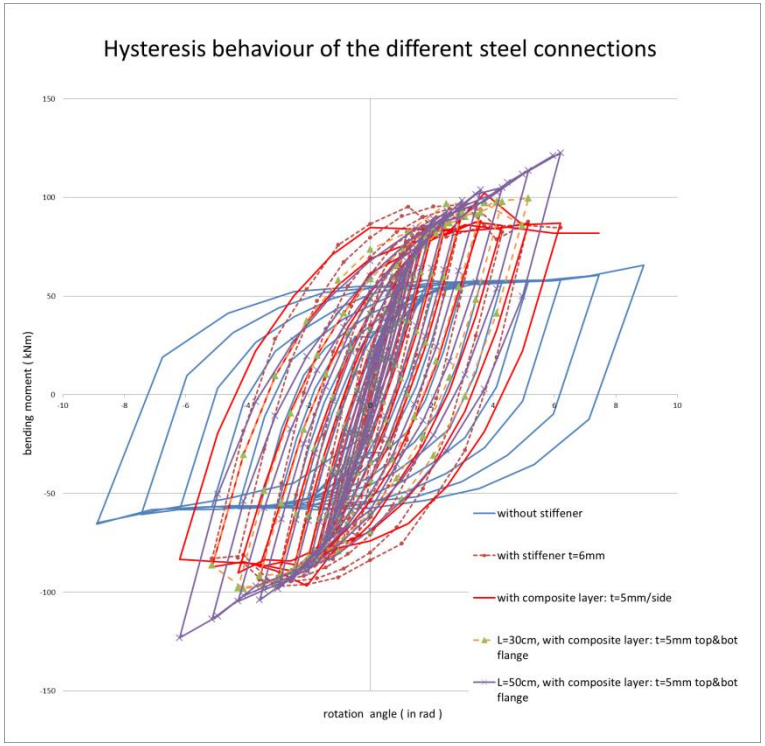
Steel connections earthquake loading

Only 5 mm in the section joint and strengthened flanges





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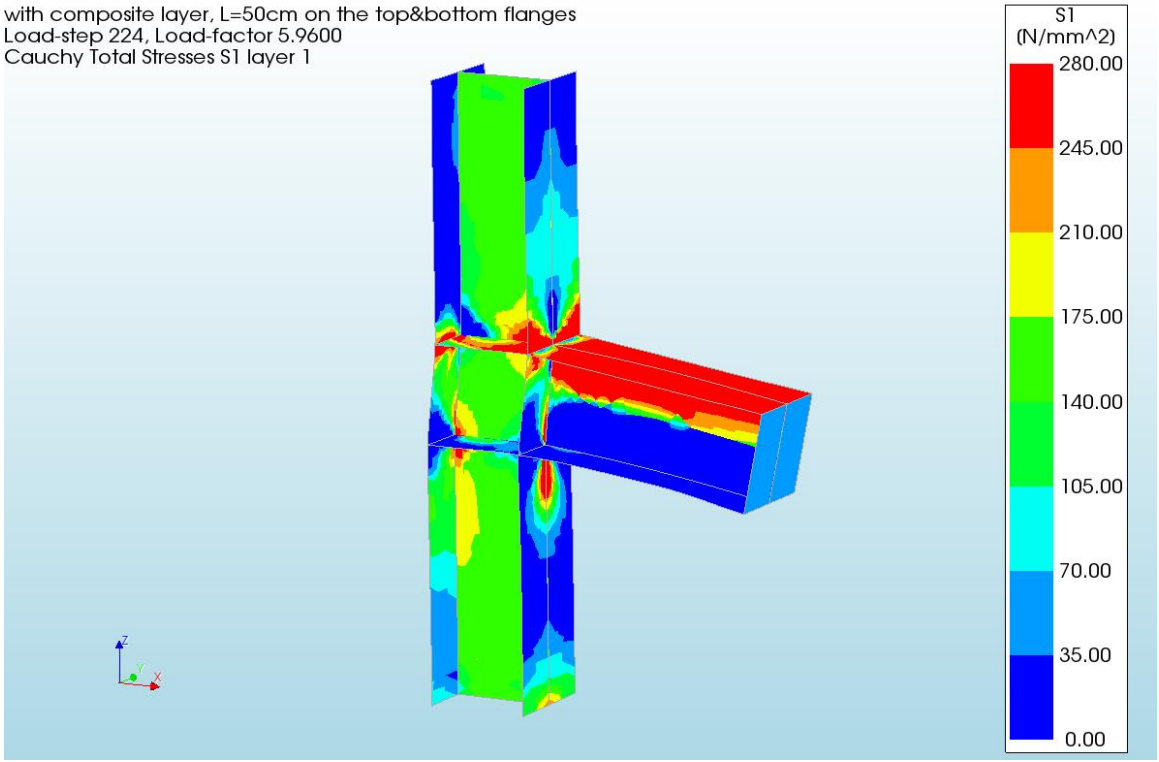
Steel connections earthquake loading

Stress in the steel sections



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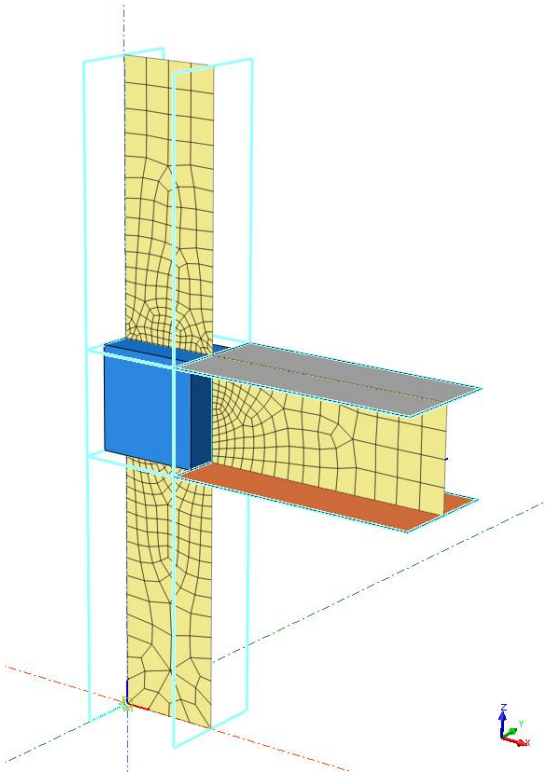
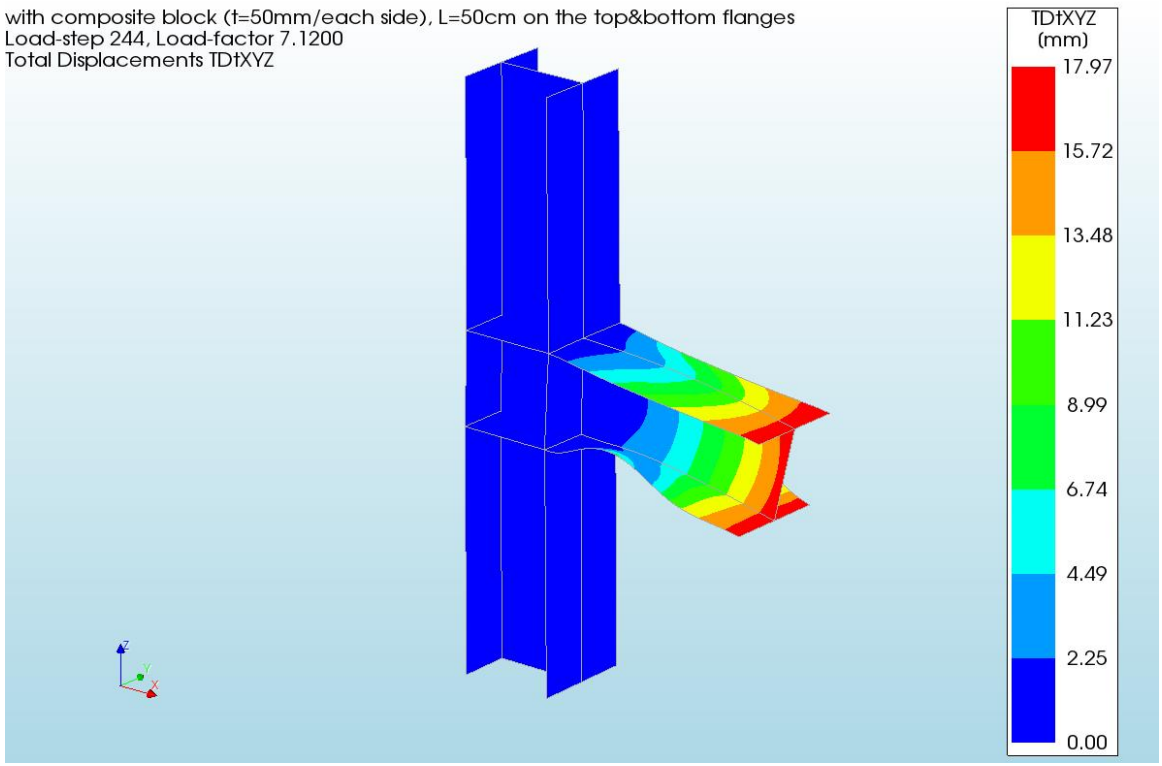
Steel connections earthquake loading

Composite block: t=50mm/side at the crossing and t=5mm for the top&bottom flanges.

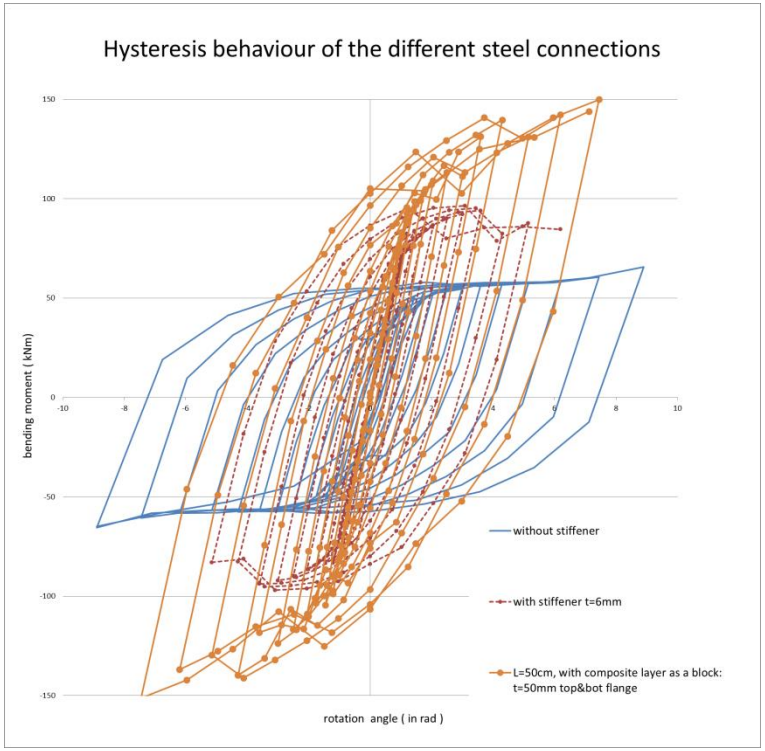




Steel connections earthquake loading

with 50 mm in the section joint

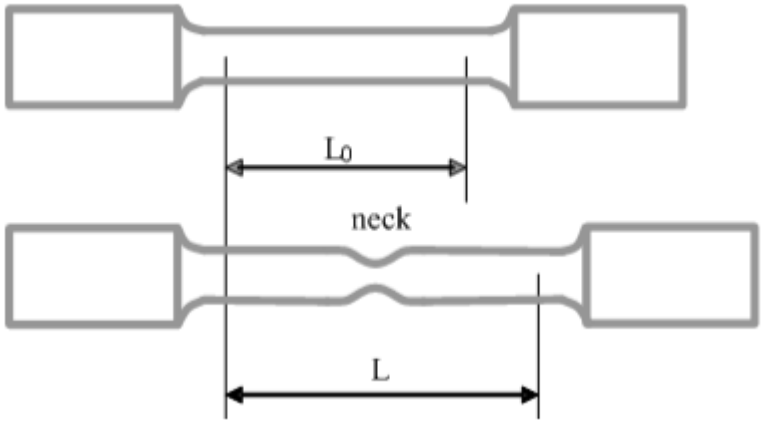
Stronger and only little bit less ductile in bending.

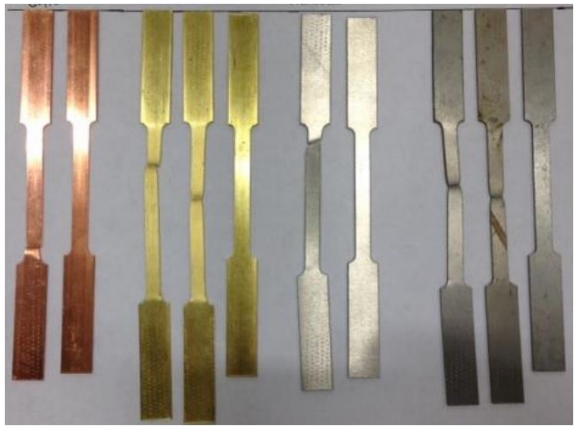


Steel localisation

Tensile specimen as example

Rupture somewhere in the reduced area.

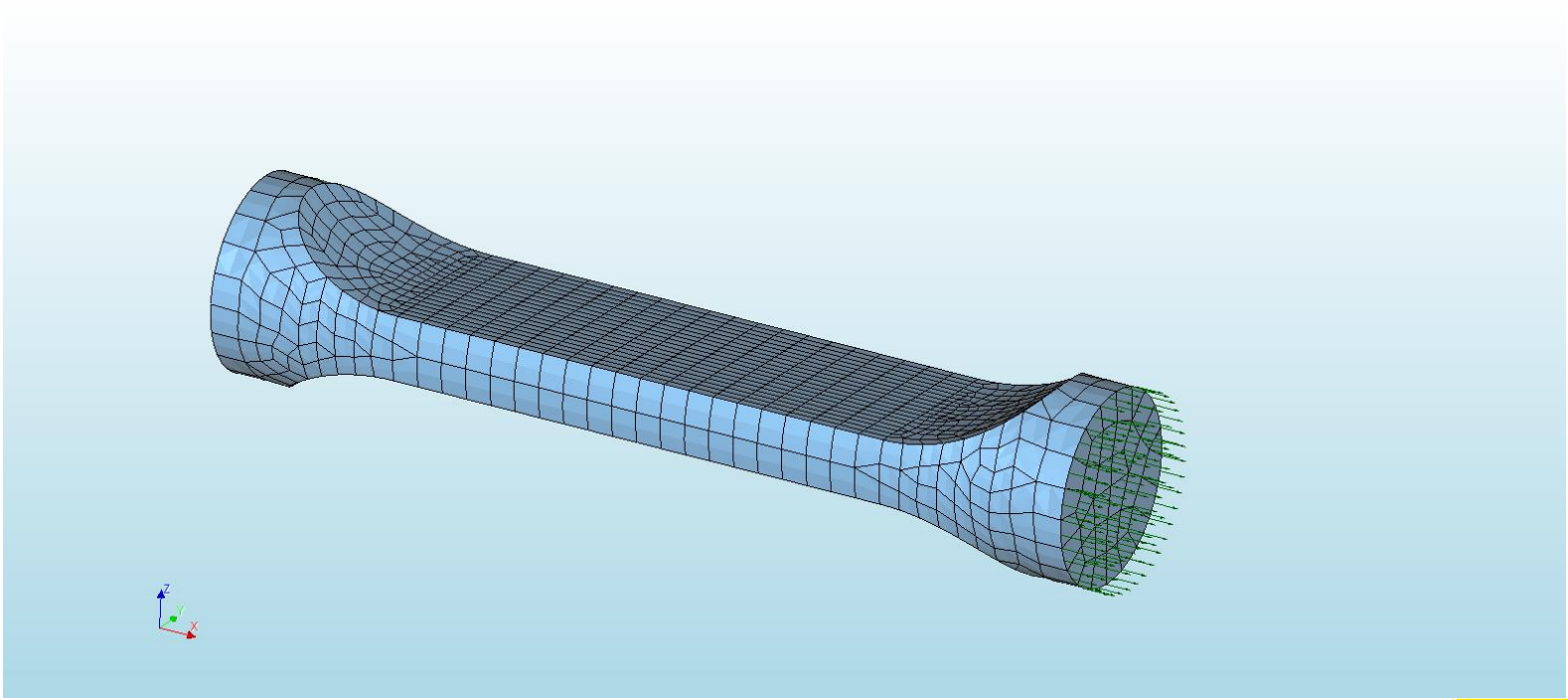




Steel localisation

Tensile specimen as example

Input model.

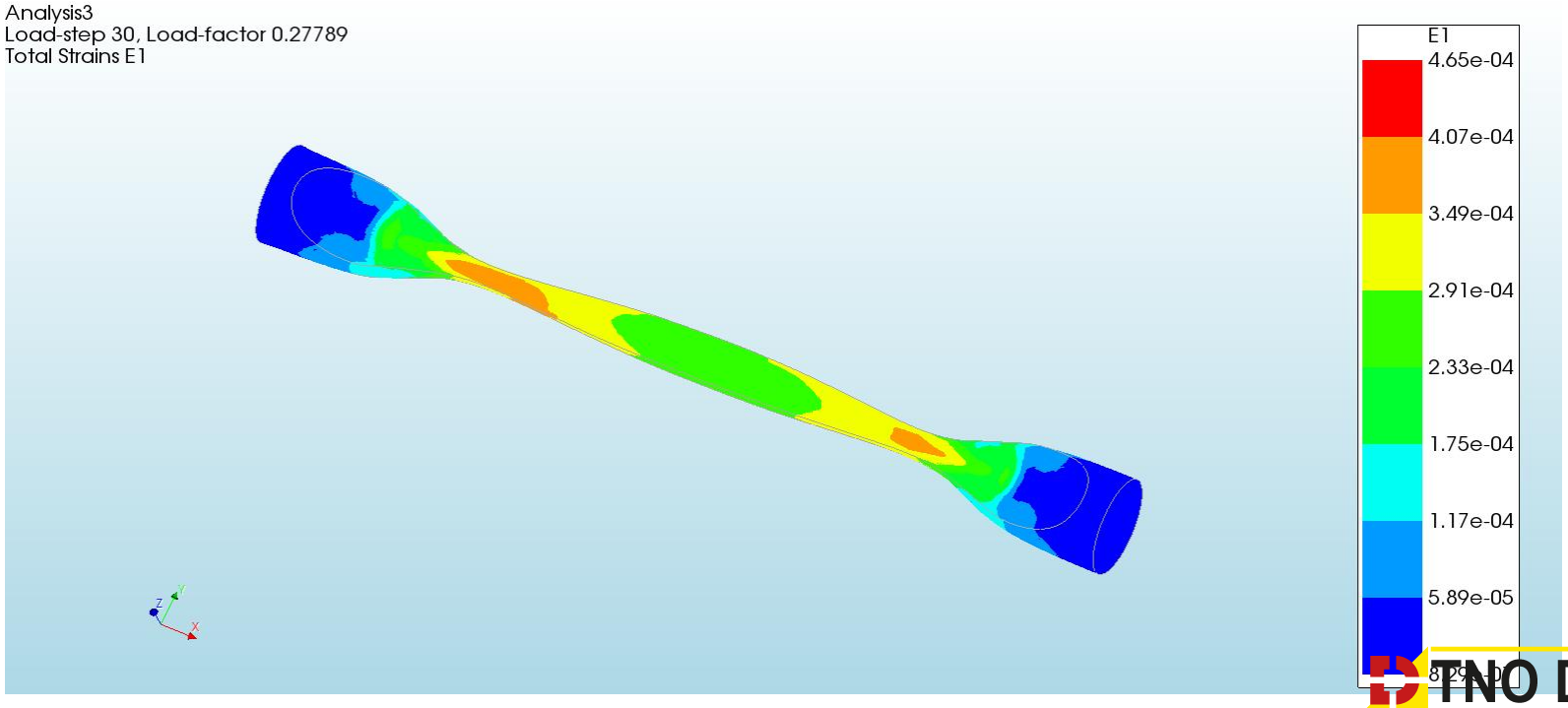


Steel localisation

Tensile specimen as example

Output stress is constant over the length.

Where to plasticize, left, middle or both ??

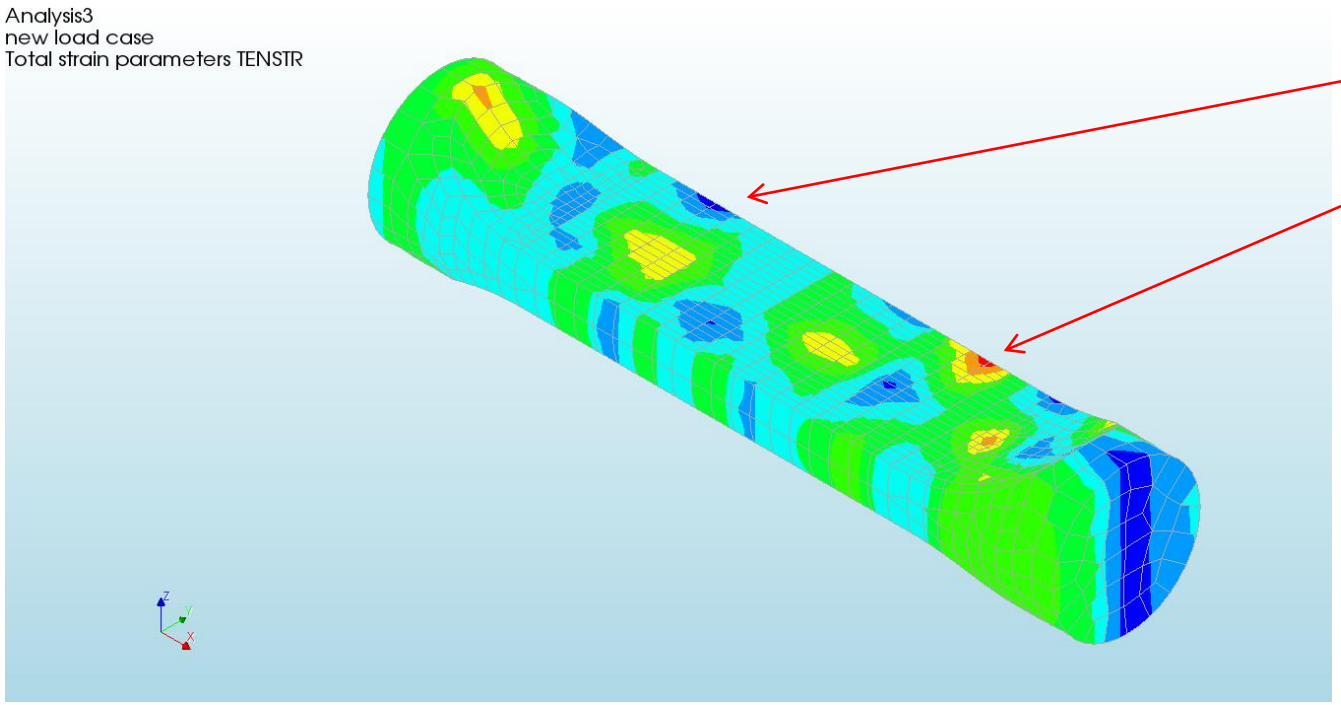


Steel localisation

Tensile specimen as example

Output stress is constant over the length.

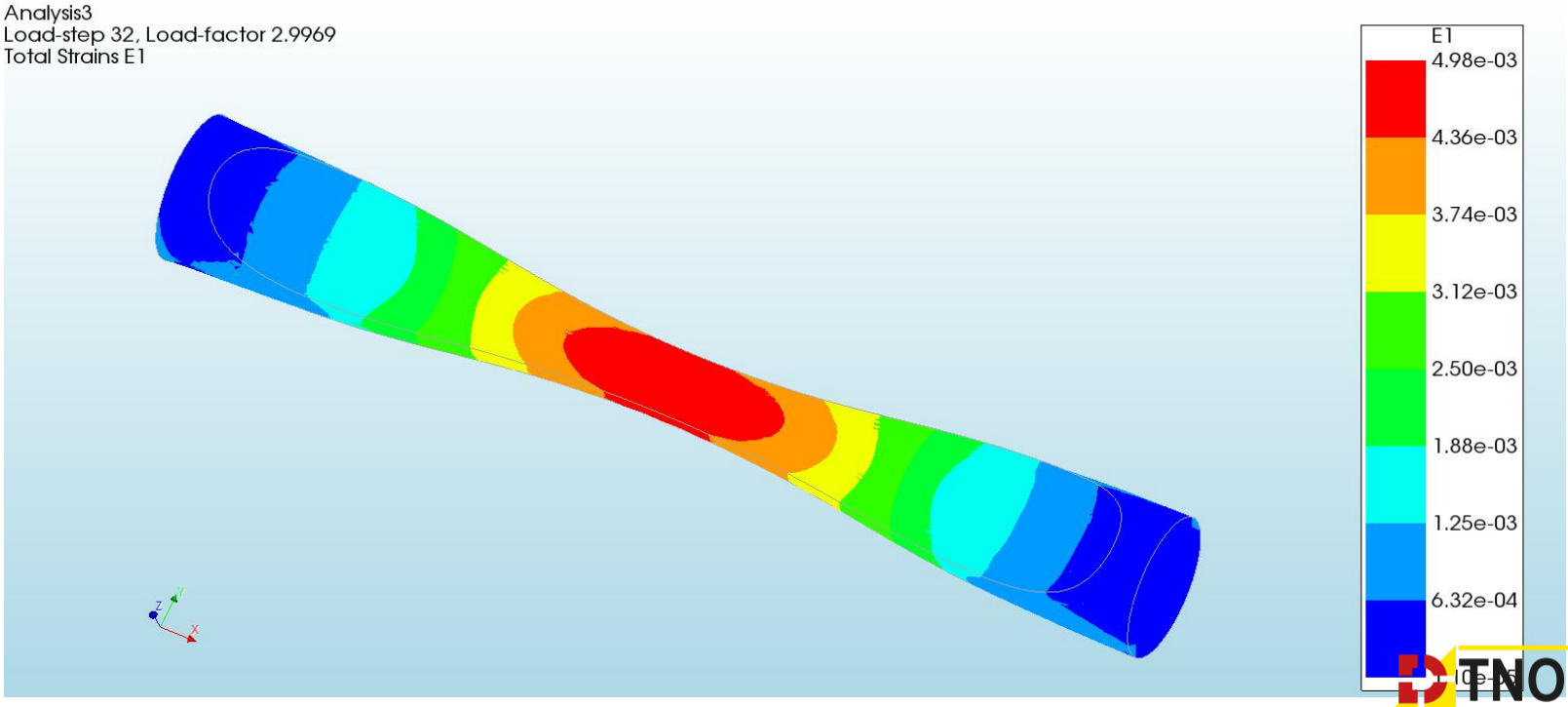
Stochastic material over the model.



Steel localisation

Tensile specimen as example

Output plastic strain is introduced in weak spots and finds its way through the section.



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Is modelling difficult?

```
newProject( "tensile_test", 1 )
setModelAnalysisAspects( [ "STRUCT" ] )
setModelDimension( "3D" )
setDefaultMeshOrder( "QUADRATIC" )
setDefaultMesherType( "HEX_QUAD" )
setUnit( "LENGTH", "MM" )
setUnit( "FORCE", "N" )
#
# Setup Geometry
createCylinder( "Cylinder 1", [ 0, 0, 0 ], [ 1, 0, 0 ], 15, 140 )
createCylinder( "Cylinder 2", [ 30, -50, 35 ], [ 0, 1, 0 ], 30, 100 )
#
duplicateShape( "Cylinder 2" )
translate( "duplicate 3", [ 80, 0, 0 ] )
duplicateShape( "Cylinder 2" )
duplicateShape( "duplicate 3" )
createBlock( "Block 6", [ 30, -50, 5 ], [ 80, 100, 60 ] )
duplicateShape( "Block 6" )
#
translate( "duplicate 4", [ 0, 0, -70 ] )
translate( "duplicate 5", [ 0, 0, -70 ] )
translate( "duplicate 7", [ 0, 0, -70 ] )
#
subtract( "Cylinder 1", [ "Cylinder 2", "Block 6", "duplicate 3", "duplicate 4", "duplicate 7", "duplicate 5" ],
perspectiveProjection( True )
```

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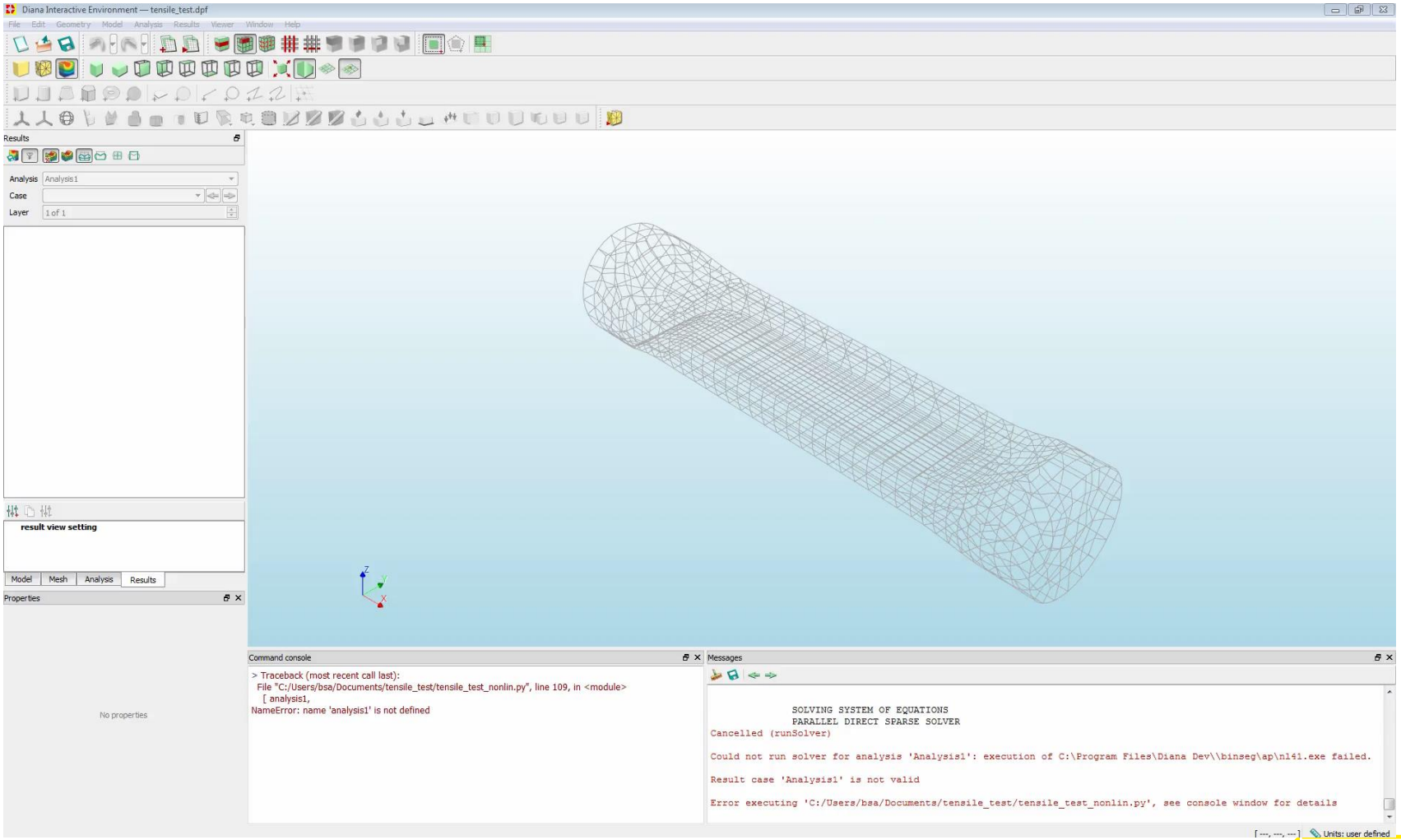
Is modelling difficult?



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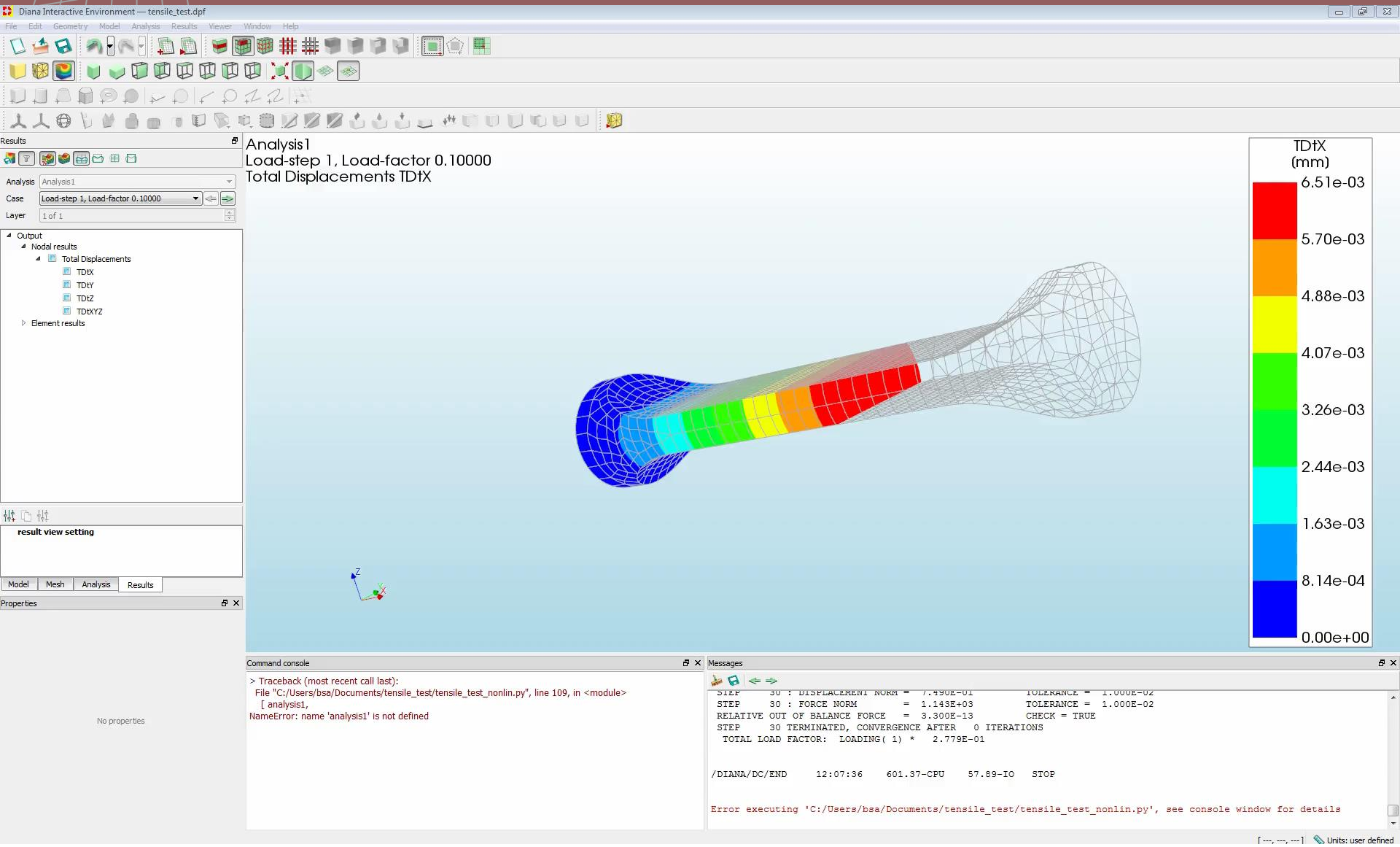

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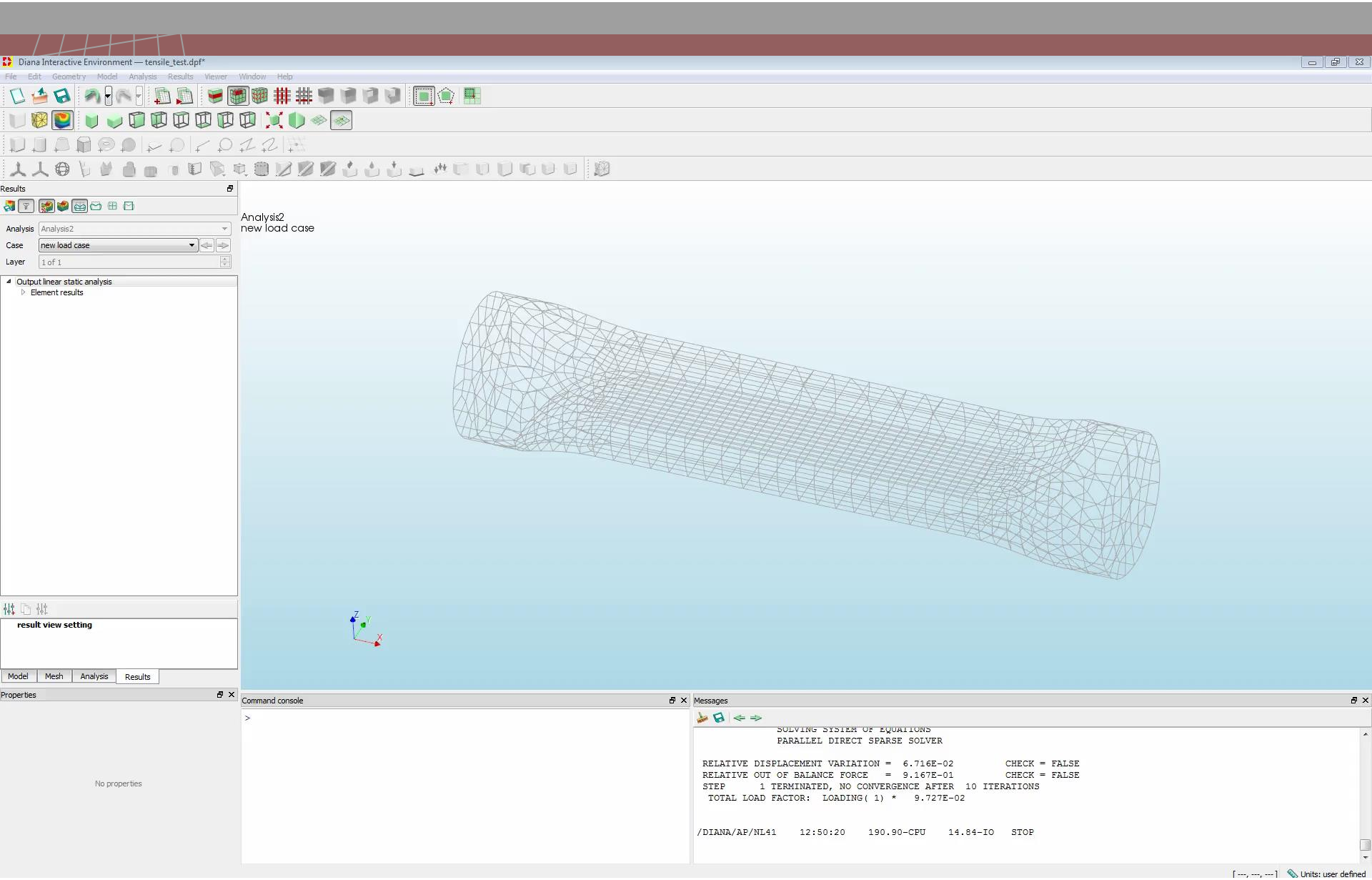

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See you at our stand ?

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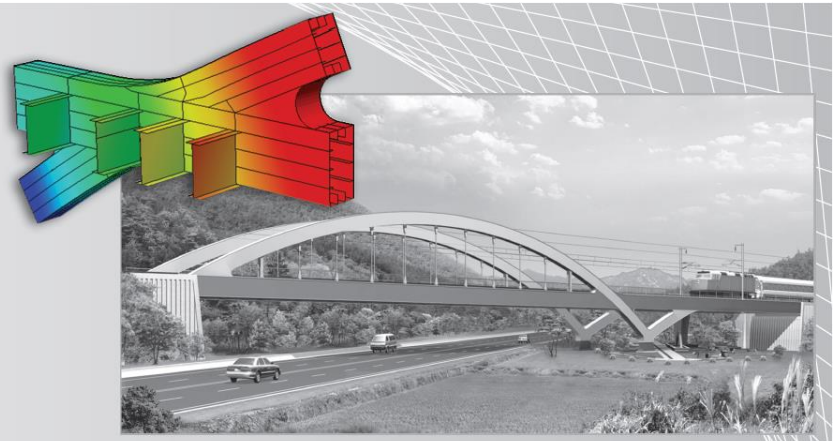
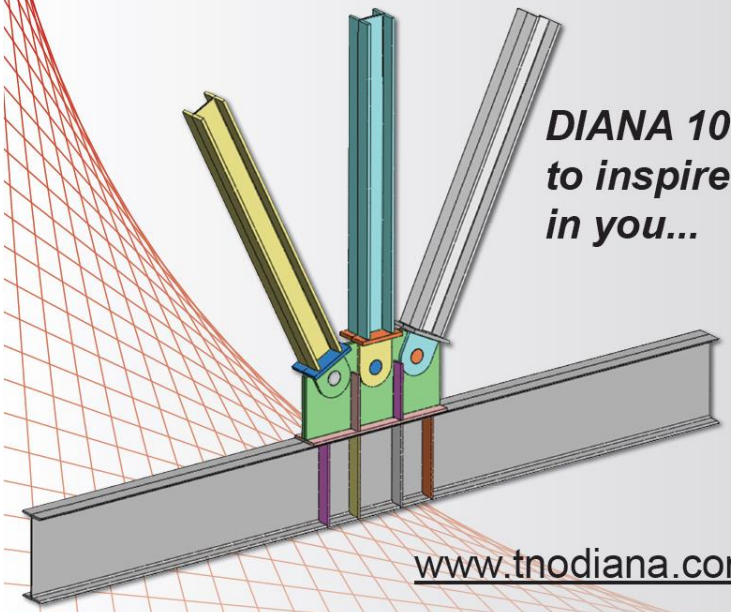
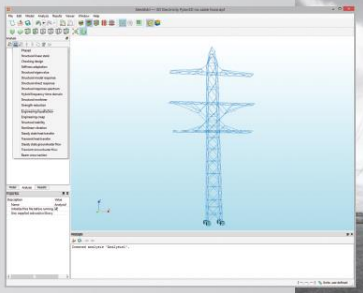
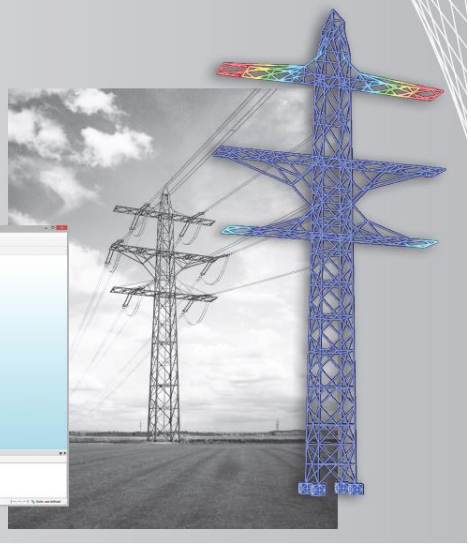
Create your model. Set your parameters in your own script... simply more productive!





DIANA 10 - Finite Elements to inspire the Civil Engineer in you...





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