IFC-Driven Code_Aster Analyses for Buildings

Ioannis P. Christovasilis
Lorenzo Riparbelli

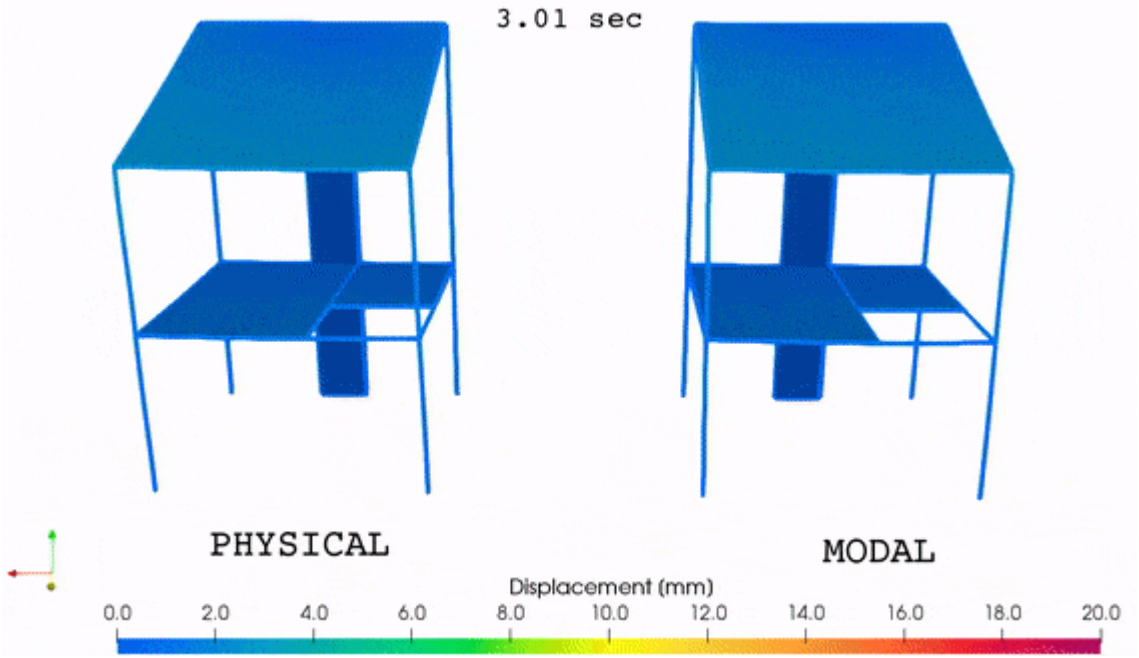
code_aster ProNet

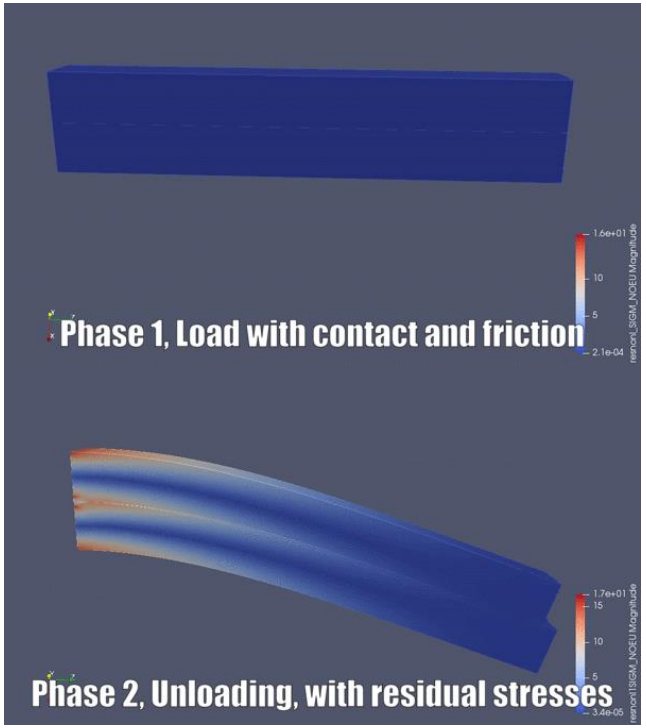
ProNET Meeting
May 20, 2021

aether ENGINEERING

Aether Engineering

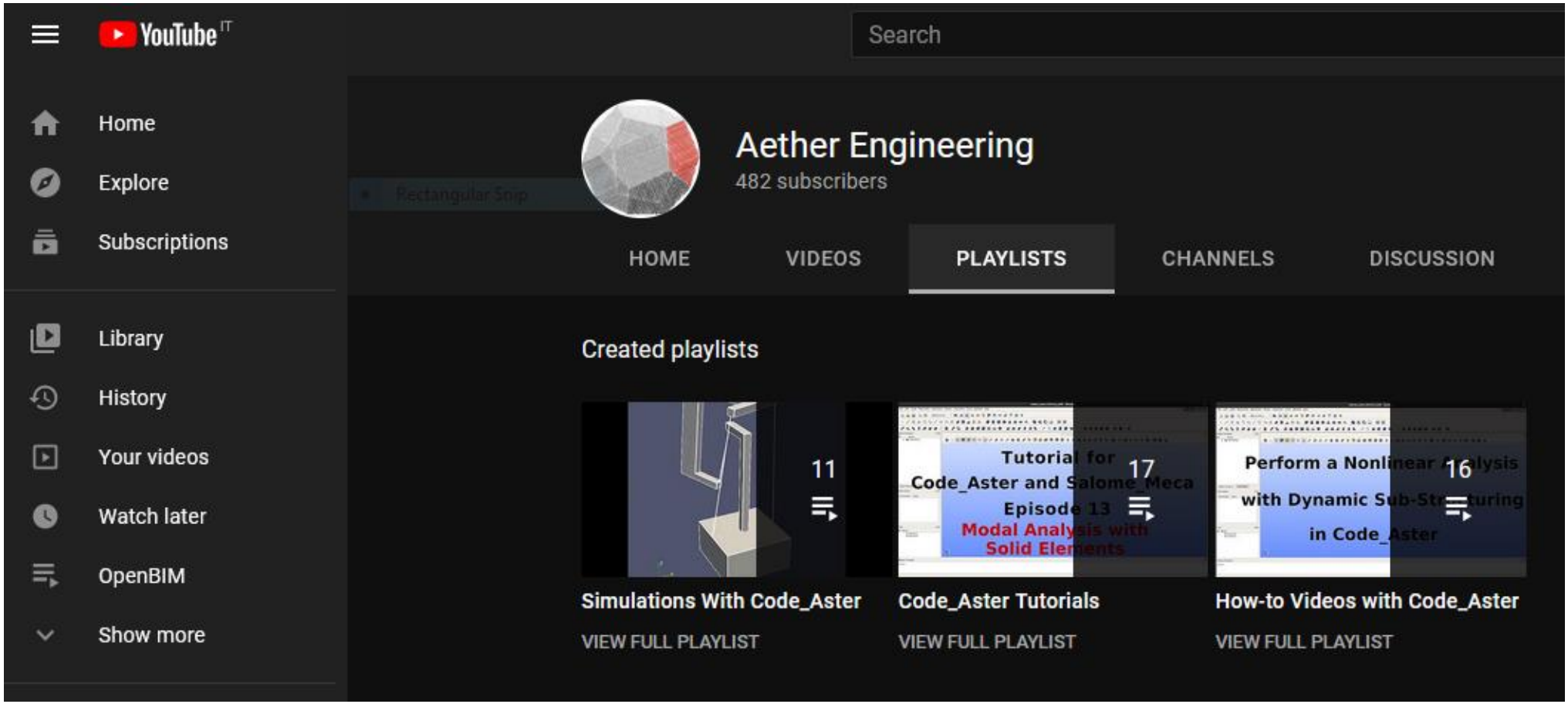
- Engineering & Software Company in Florence, IT
- Code_Aster users from day 1 (> 5 years)
- Structural - Civil and Mechanical Sector





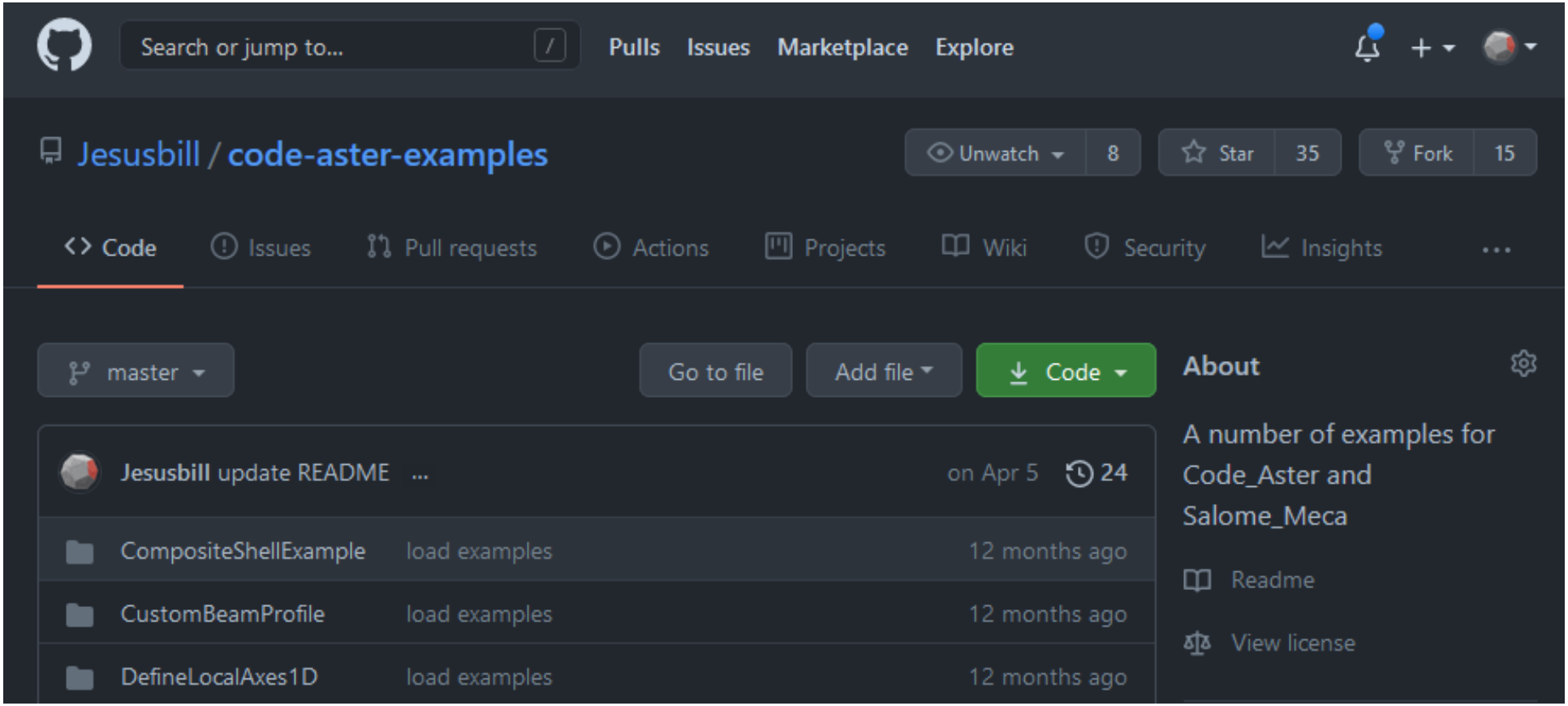
Aether Engineering

- YouTube channel with Tutorials and How-to Video



Aether Engineering

- YouTube channel with Tutorials and How-to Videos
- GitHub repository with all files to run CA



IFC-Driven Code_Aster Analyses for Buildings

- Need for a data schema that covers the specific aspects of buildings;
  a layer of abstraction above the typical layer of a finite-element analysis pipeline

IFC-Driven Code_Aster Analyses for Buildings

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- Need for **BIM** … Building Information Modelling

IFC-Driven Code_Aster Analyses for Buildings

- Need for a data schema that covers the specific aspects of buildings;
  a layer of abstraction above the typical layer of a finite-element analysis pipeline
- Need for **BIM** … Building Information Modelling
- Use **IFC**, the established openBIM ISO standard, for the description of the building data

openBIM -> vendor-agnostic / libre / collaboration

IFC-Driven Code_Aster Analyses for Buildings

Industry Foundation Class - IFC:

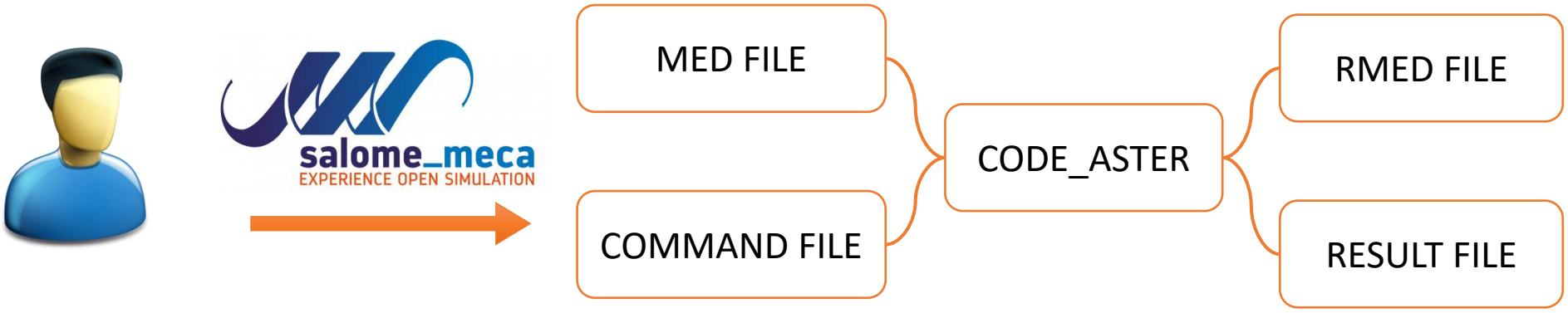
- Developed by buildingSMART International (bSI)
- Provides a complete set of data models for the description of building assets in all needed disciplines of the Architecture, Engineering and Construction (AEC) Sector
- It includes entities specific for Structural Analysis!!

IFC-Driven Code_Aster Analyses for Buildings

- Present some of the fundamental Open Source projects related to the IFC format and to the structural engineering domain
  - Blender and the BlenderBIM Add-on
  - ifc2ca: IFC-To-Code_Aster
  - adapy: Assembly for Design and Analysis

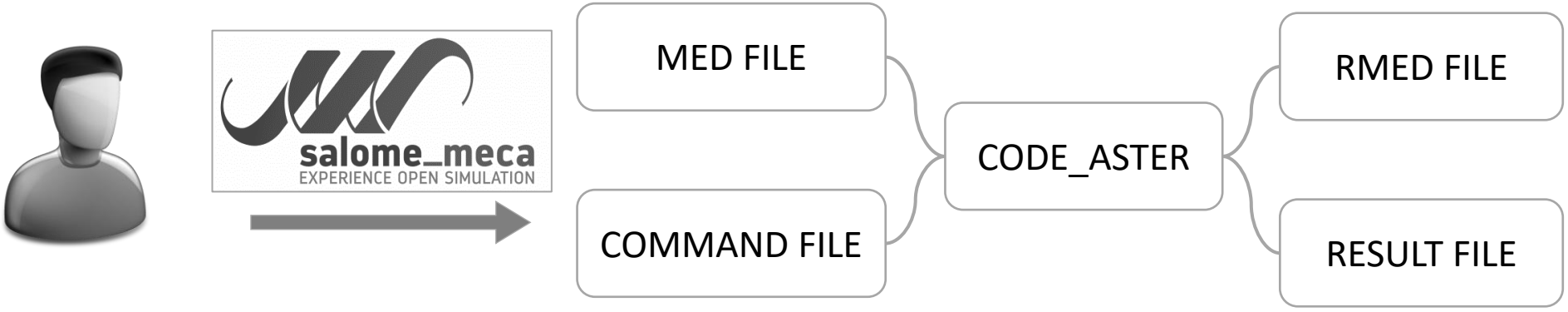
Structural Workflow with Code_Aster

- Traditional FEM Pipeline

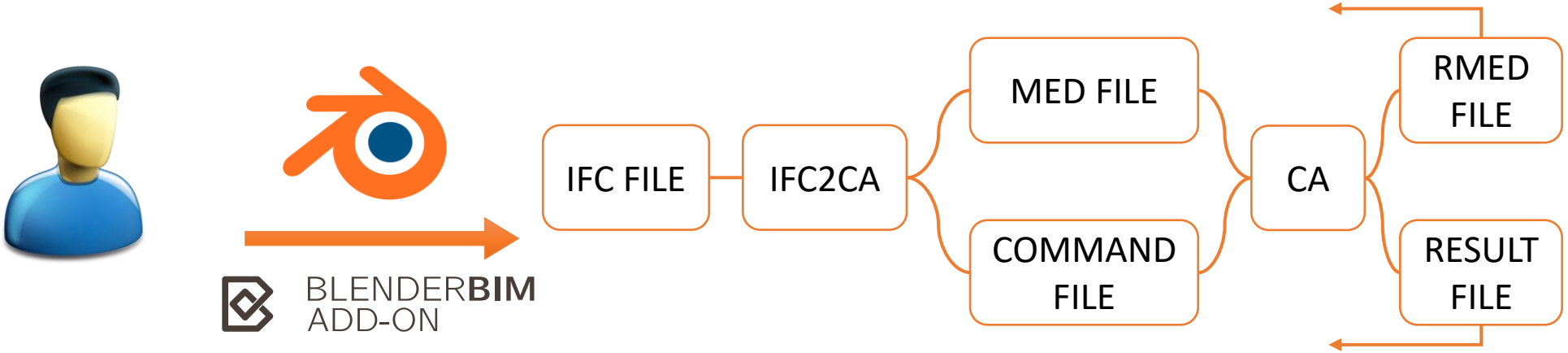


Structural Workflow with Code_Aster

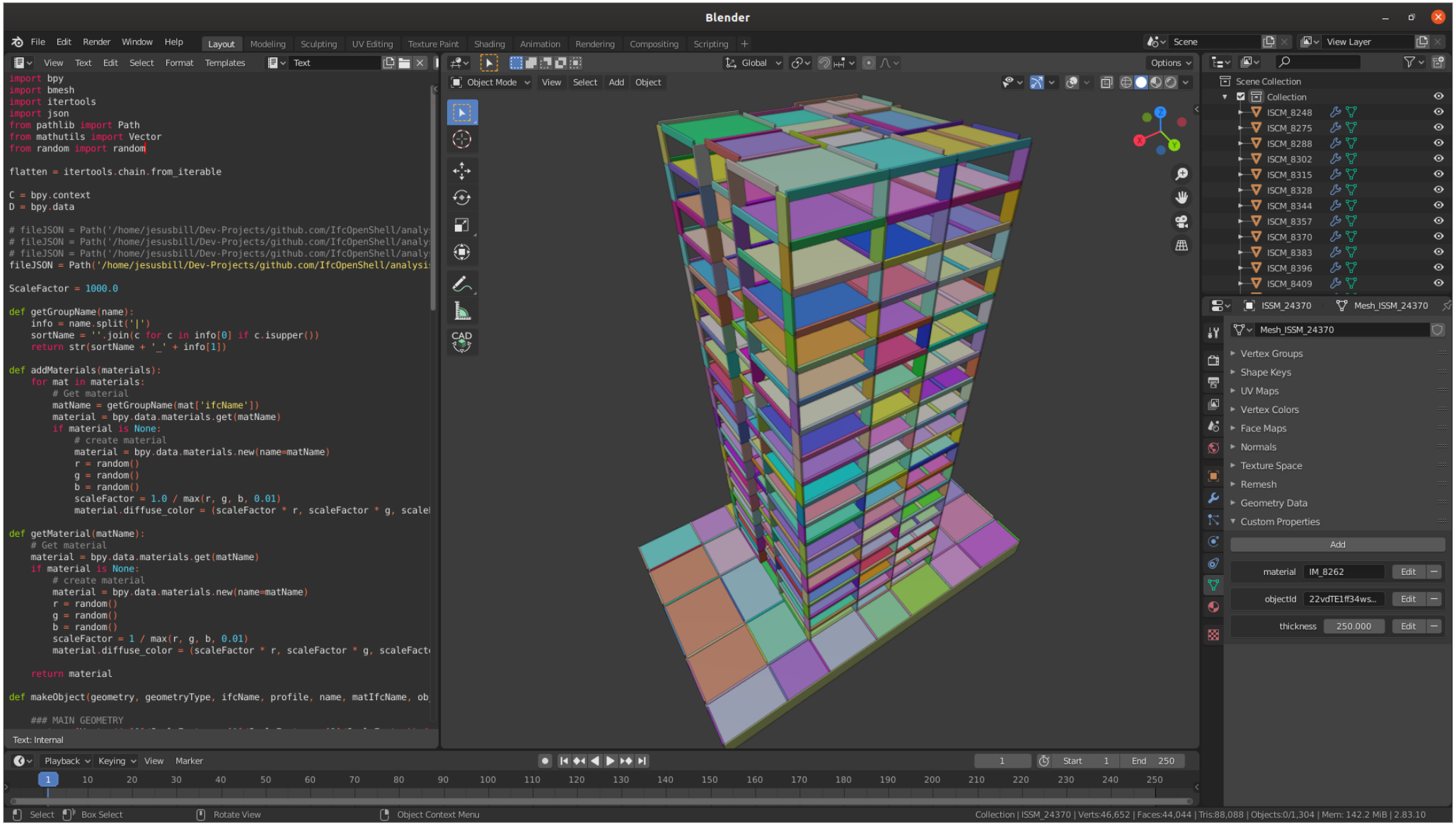
- Traditional FEM Pipeline



- openBIM Structural Pipeline

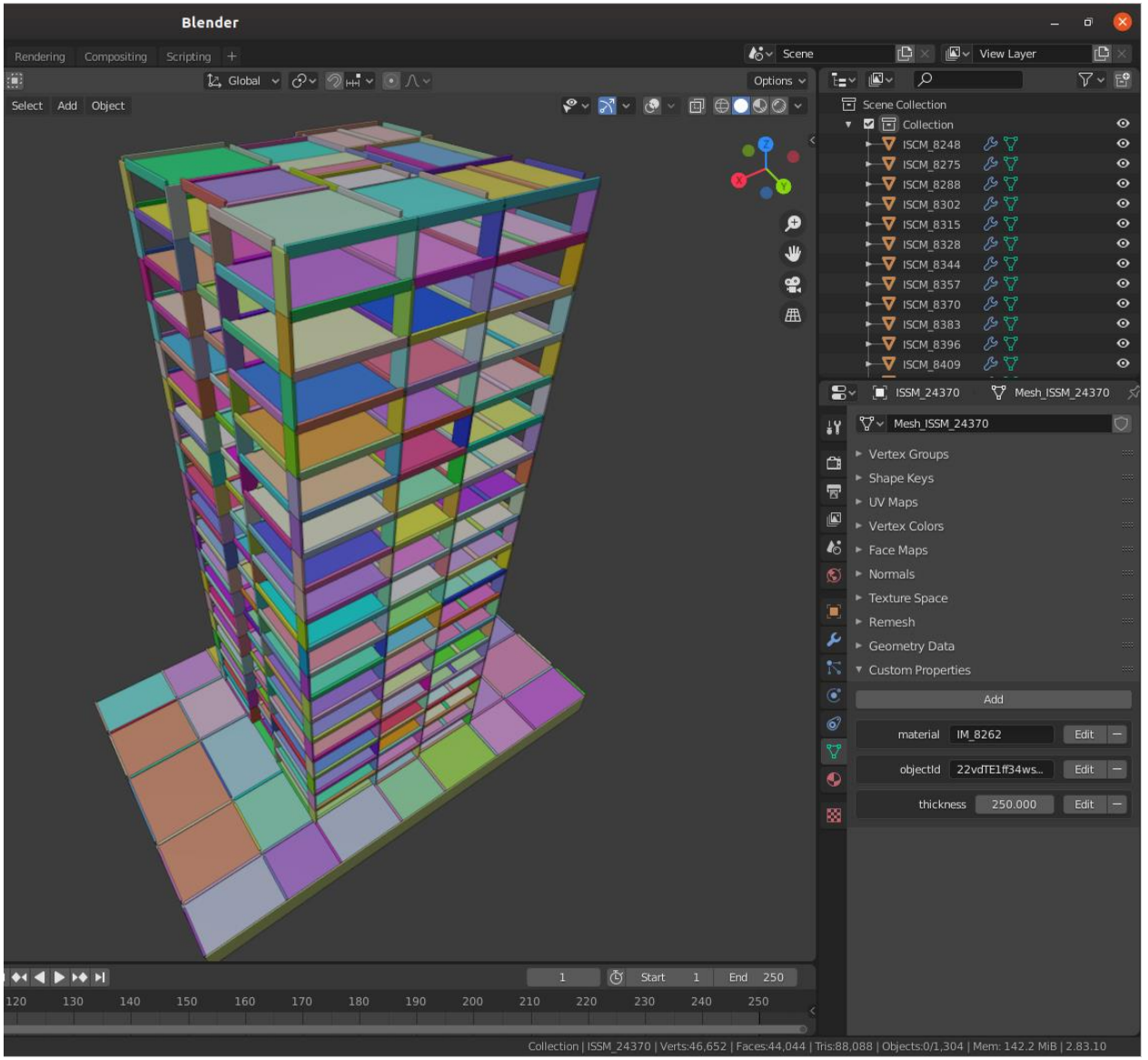


Blender and the BlenderBIM Add-On



Blender and the BlenderBIM Add-On

- OS software for CG artists
- Scene, Tree view, CAD components
- Scriptable with Python
- Add-ons as “extra” tools within the general platform



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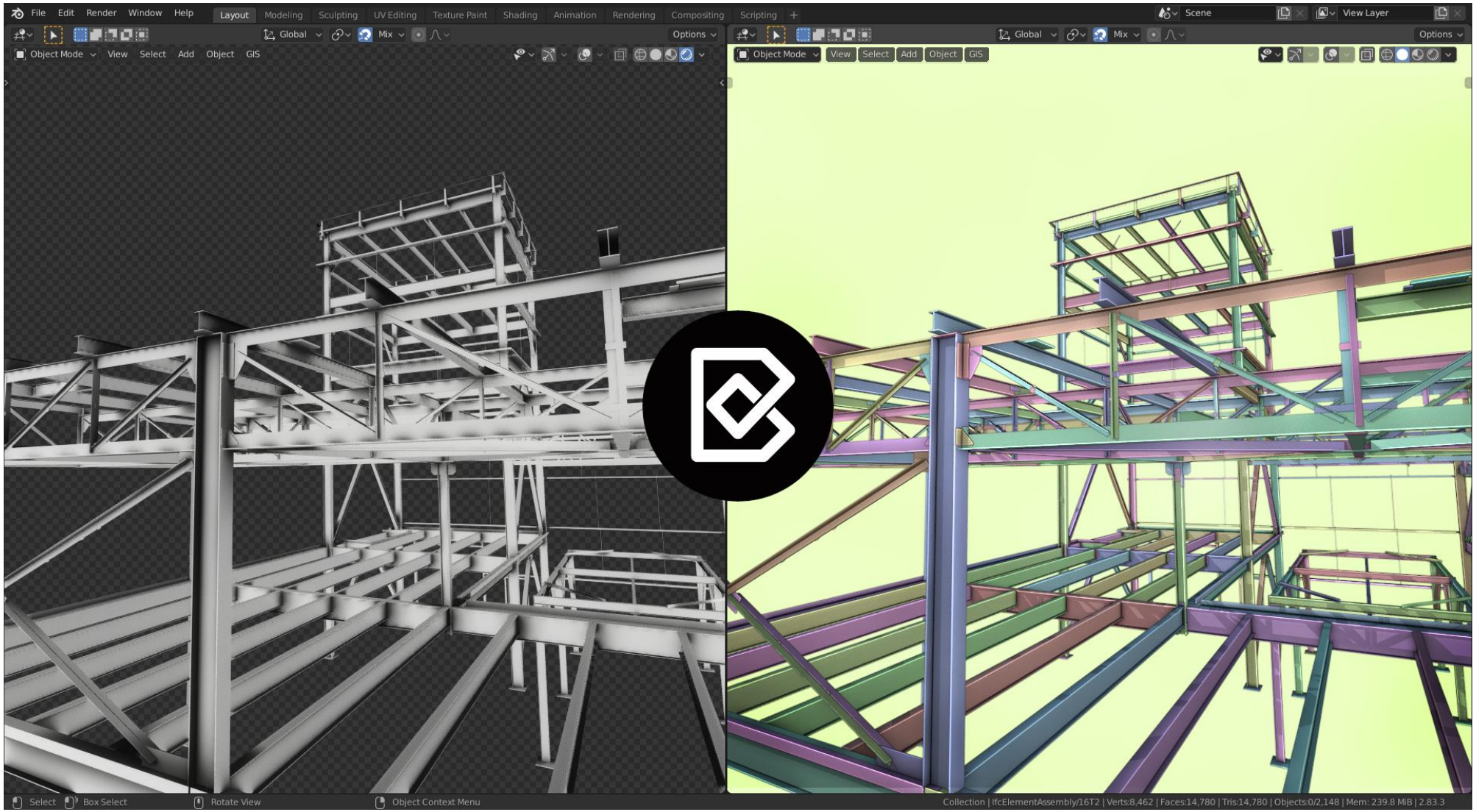
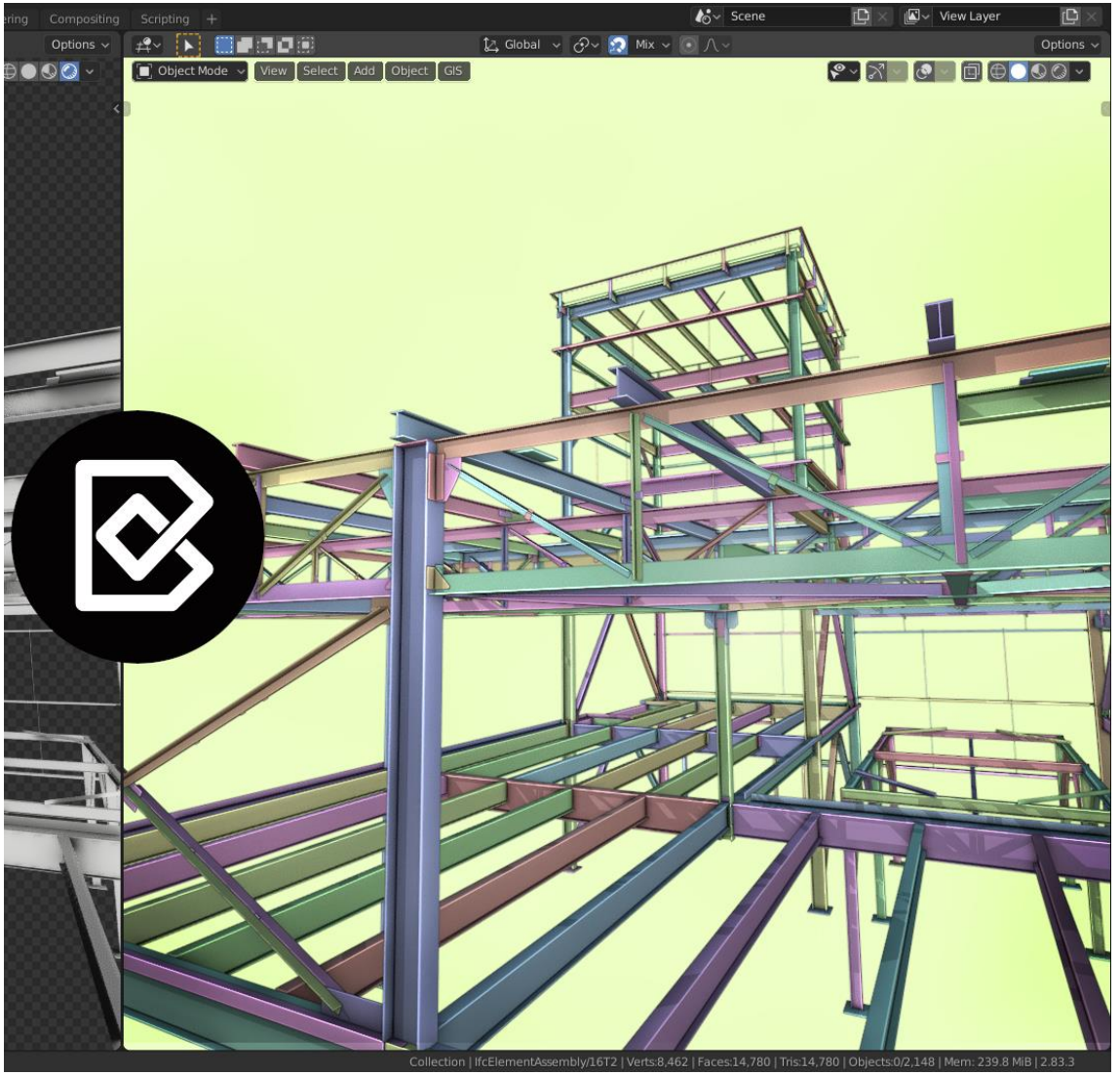


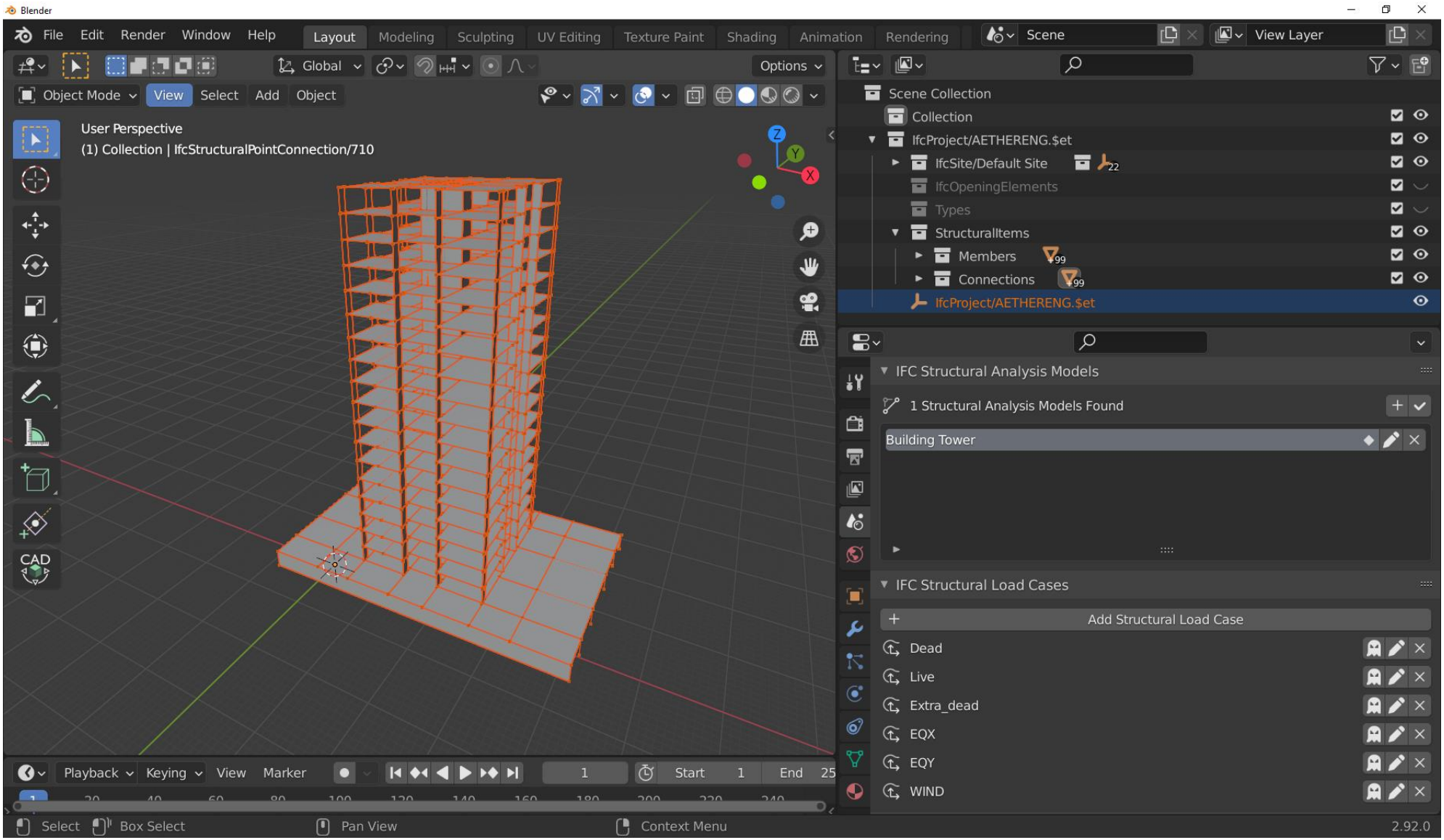
Blender and the BlenderBIM Add-On

- Started in mid 2019 by **Dion Moult**
- A general-purpose IFC authoring tool
- IFC I/O based on IfcOpenShell by **Thomas Krijnen**



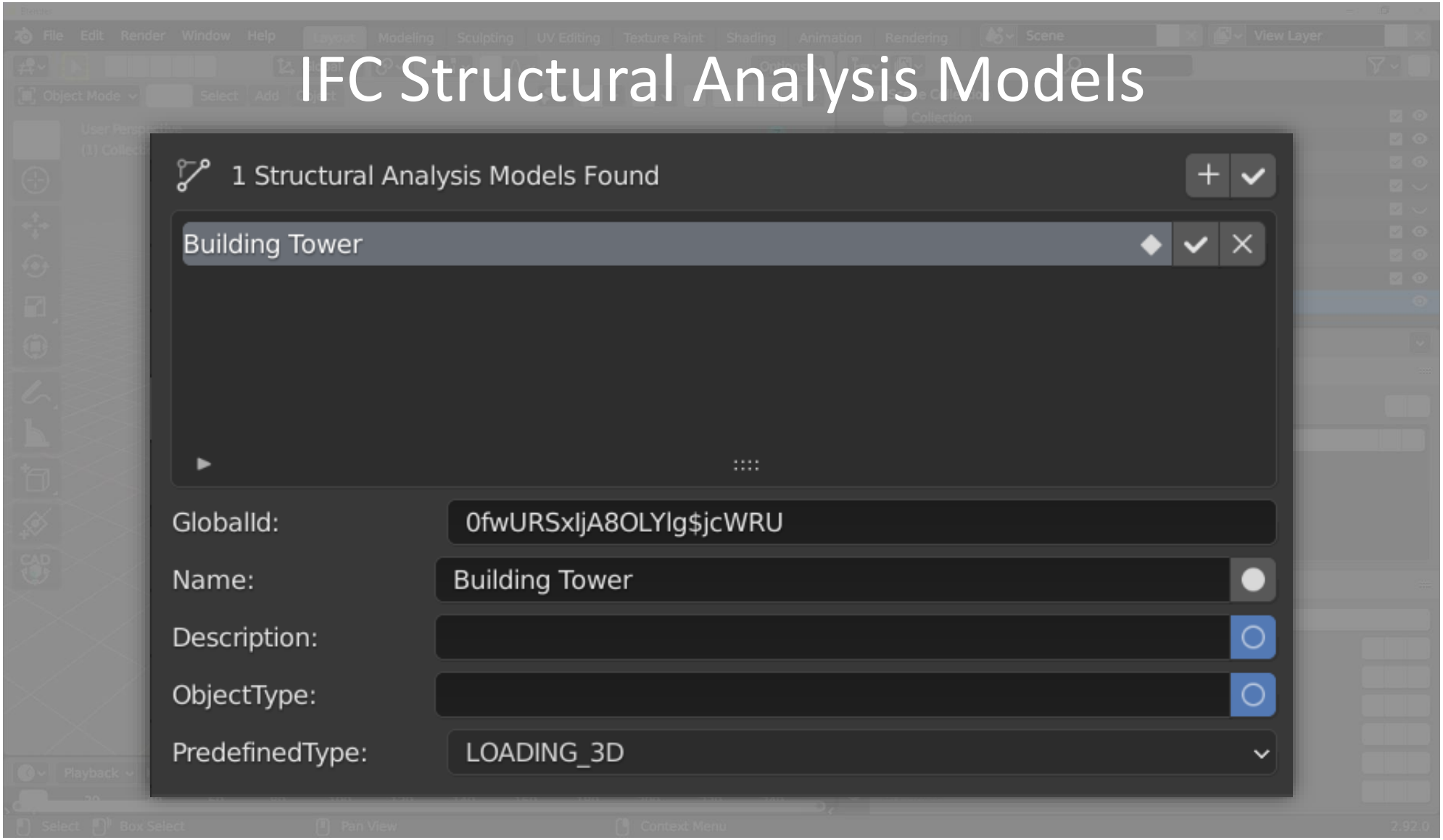
IfcOpenShell
the open source ifc toolkit and geometry engine

Blender and the BlenderBIM Add-On



Blender and the BlenderBIM Add-On

IFC Structural Analysis Models



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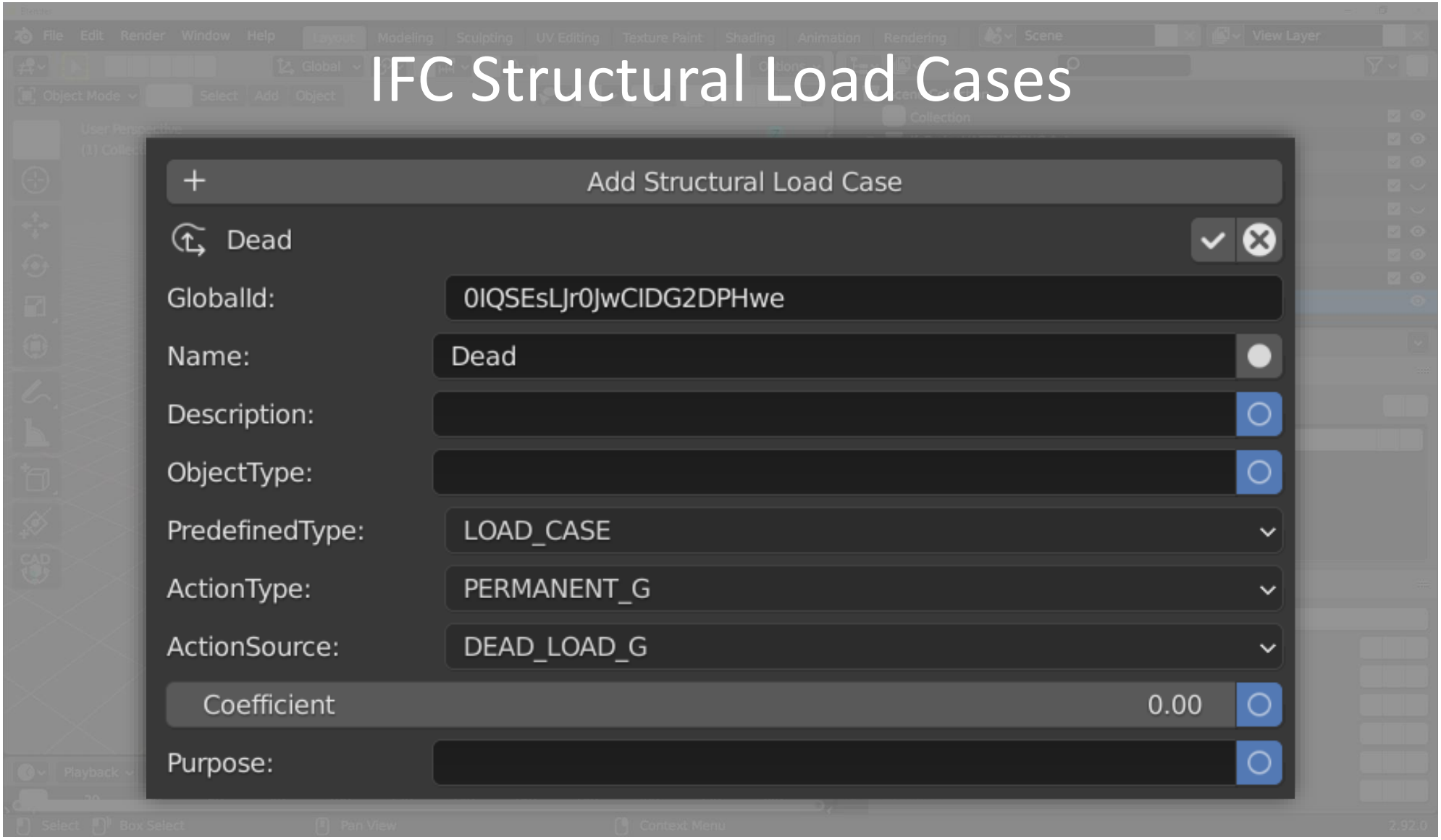
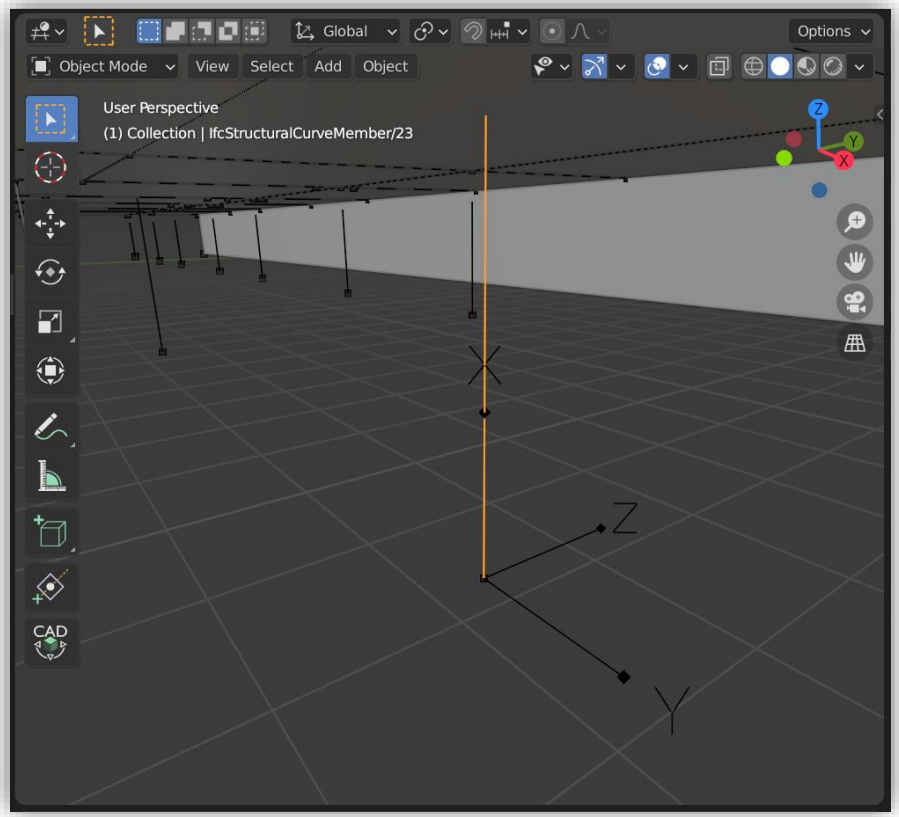
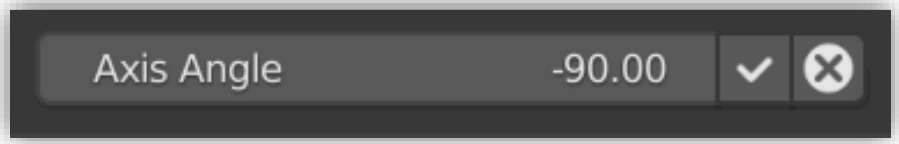
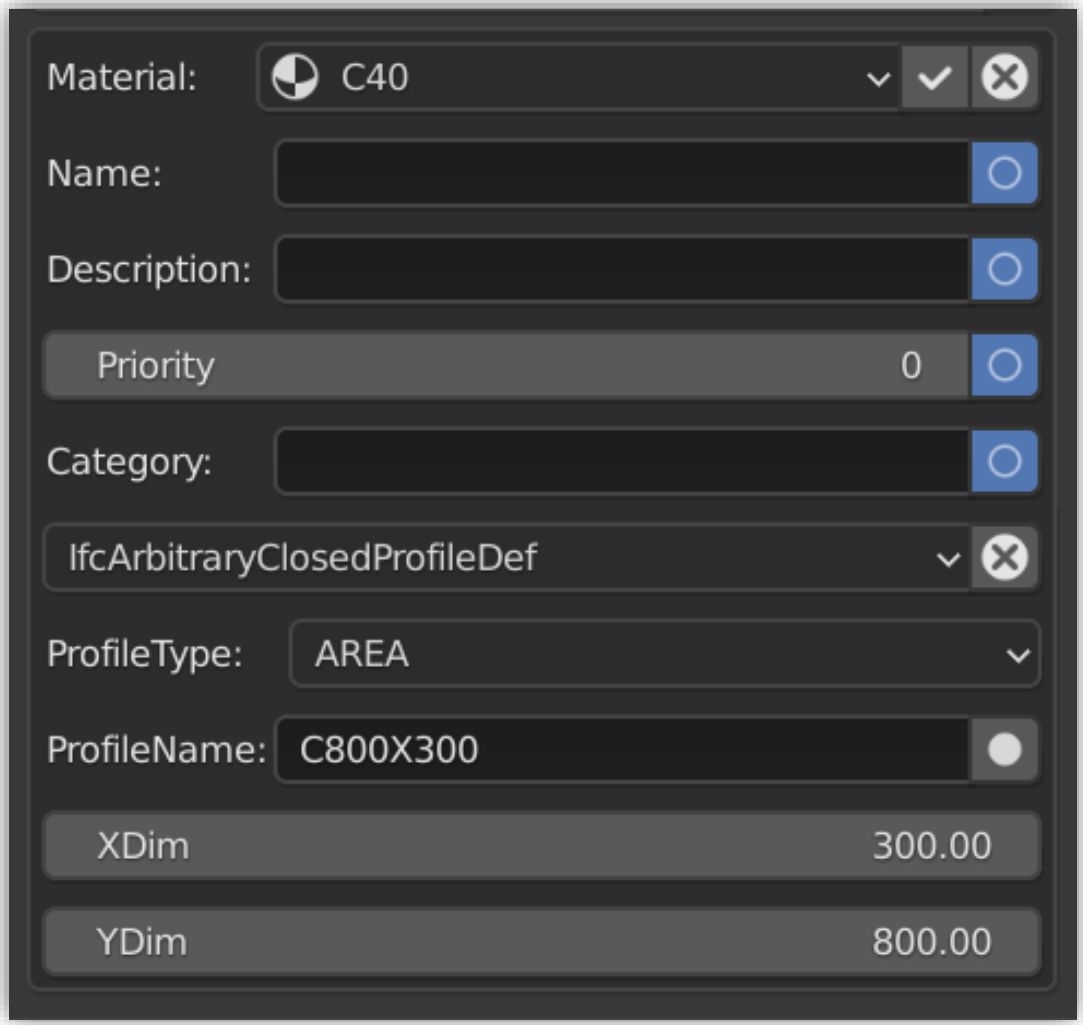


Blender and the BlenderBIM Add-On

IFC Structural Members

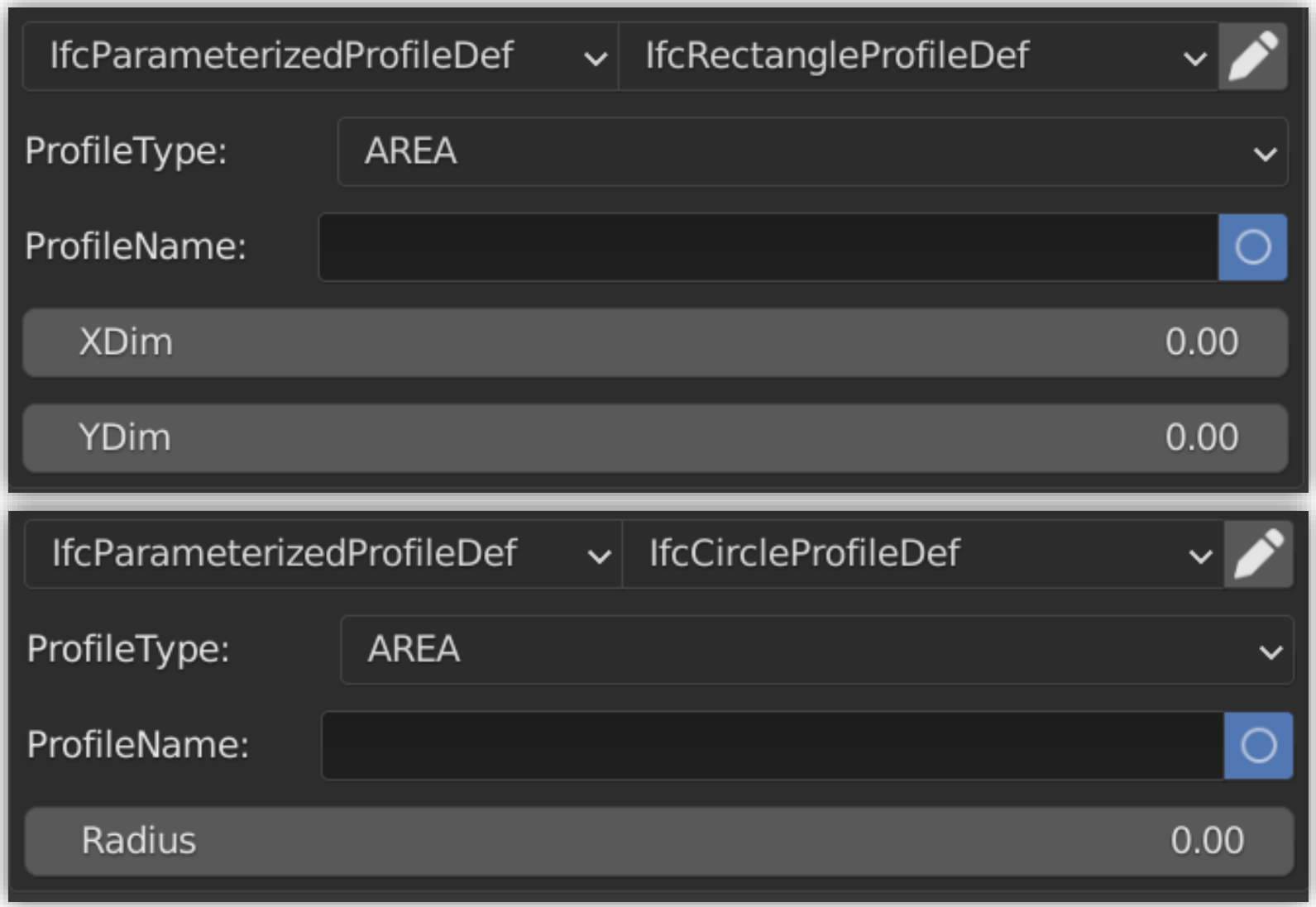






Blender and the BlenderBIM Add-On

IFC Profiles / Sections



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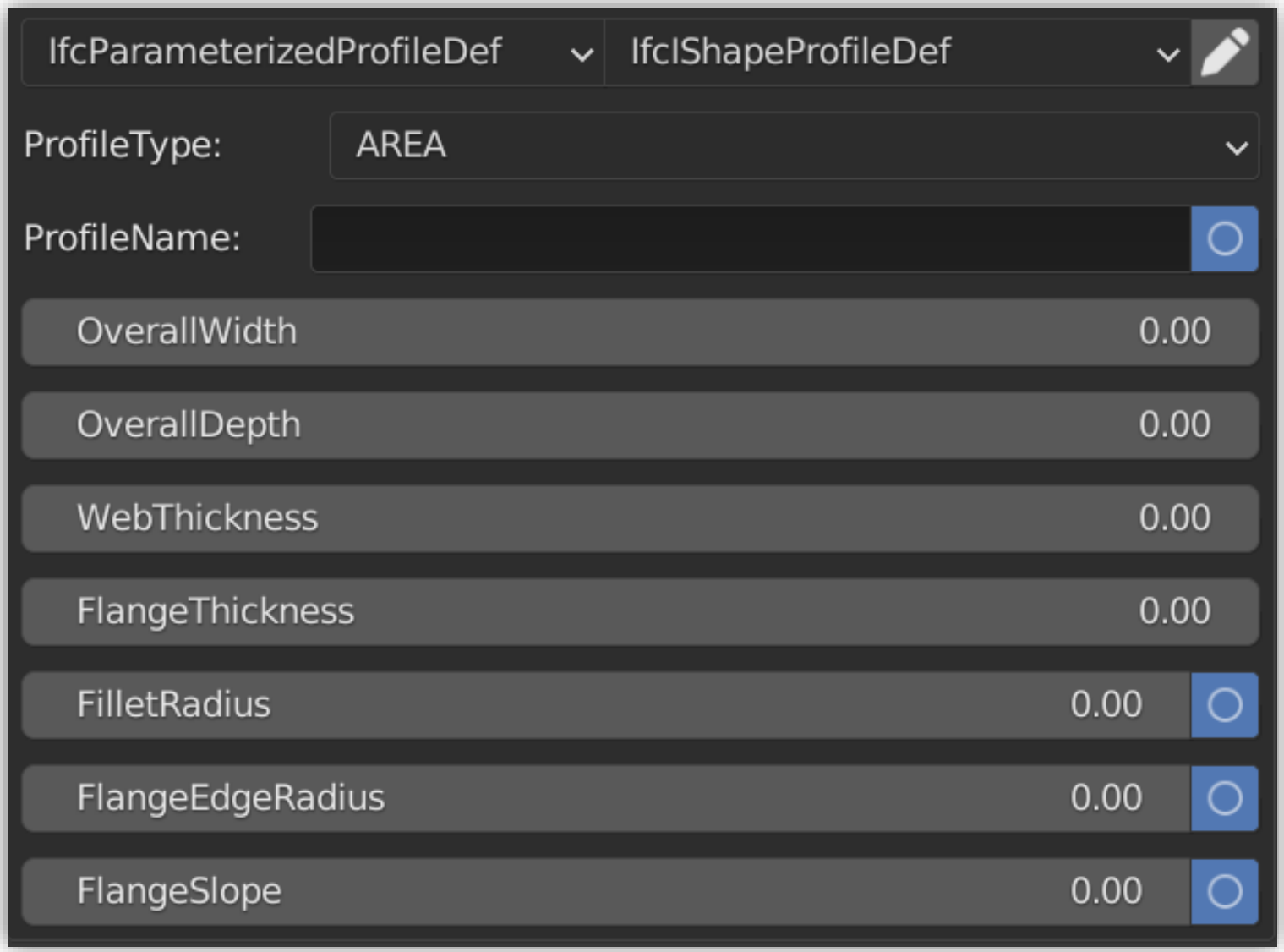
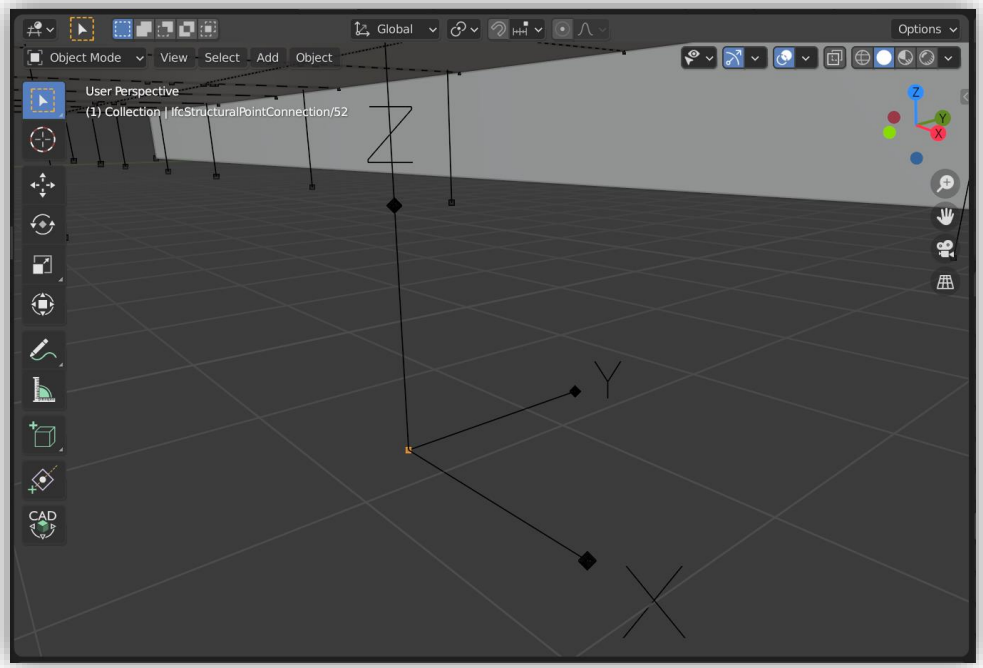
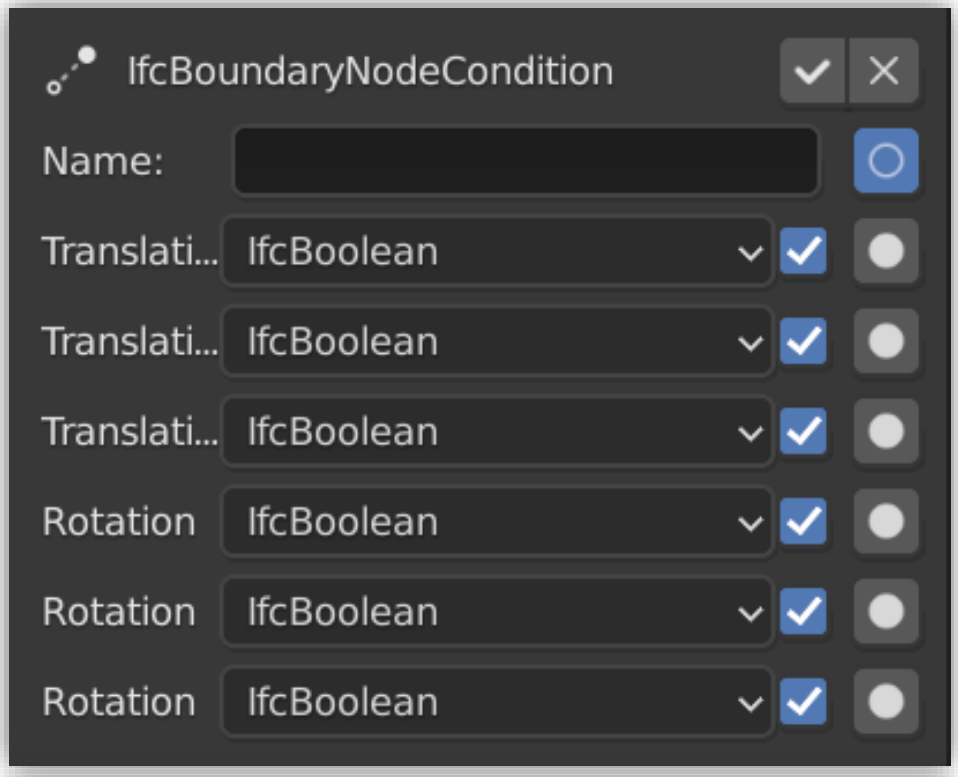
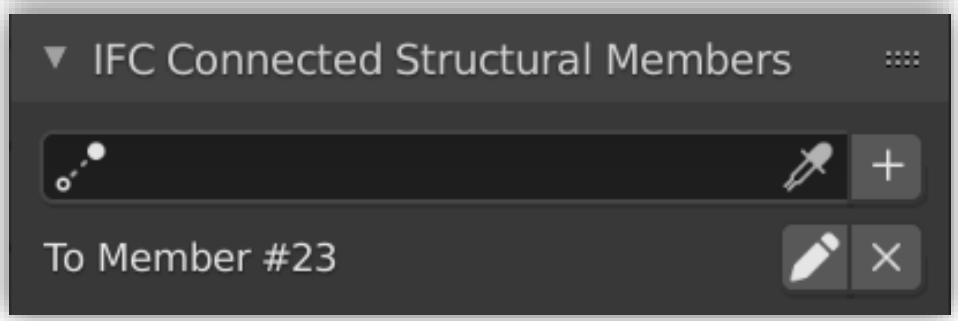


Blender and the BlenderBIM Add-On

IFC Structural Connections

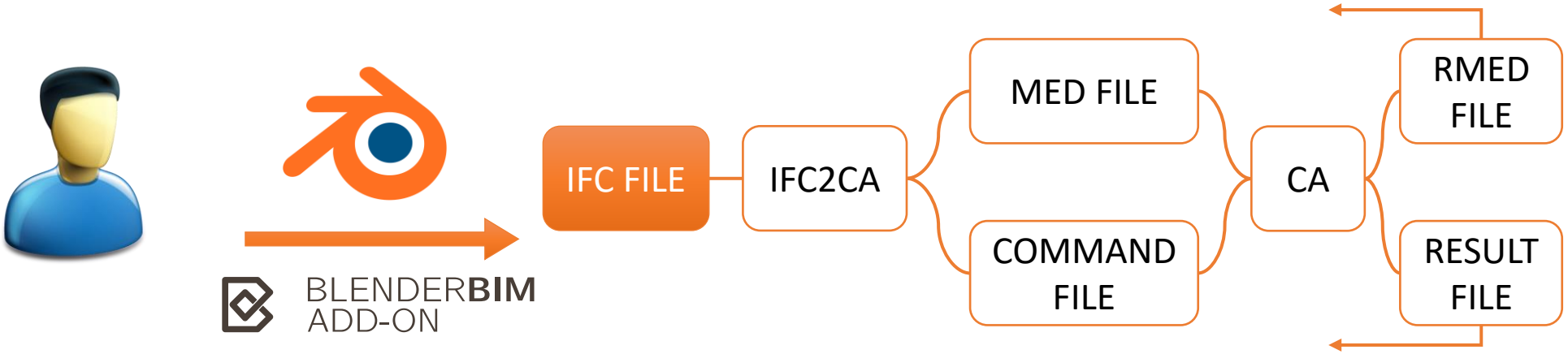






Structural Workflow with Code_Aster

- openBIM Structural Pipeline



✓ I/O with a Blender Agnostic Python Library **ifcopenshell.api**

IfcOpenShell
the open source ifc toolkit and geometry engine

Structural Workflow with Code_Aster

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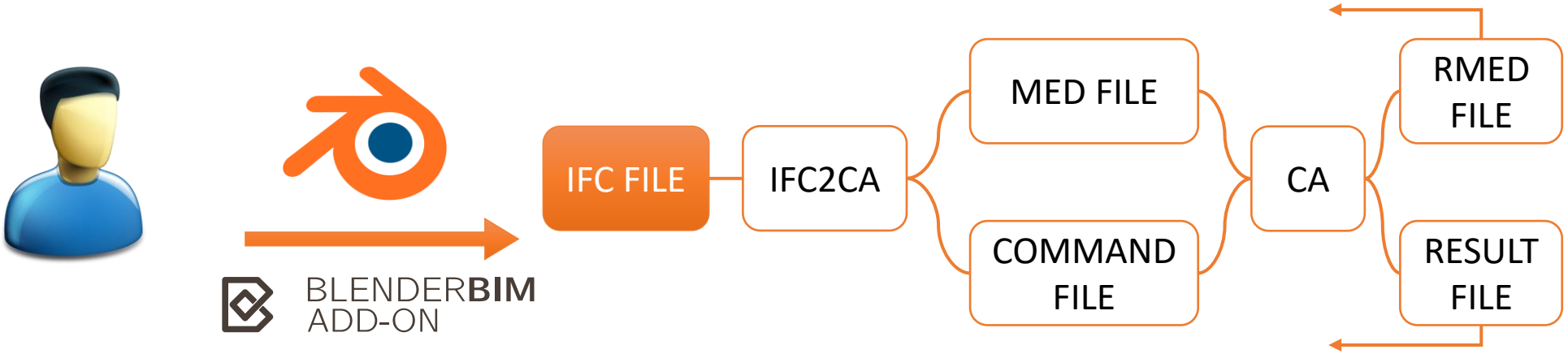

- ✓ I/O with a Blender Agnostic Python Library **ifcopenshell.api**
- ✓ Native handling of IFC files
- ✓ Specific editing of parts of an IFC file within a **Usecase**

IfcOpenShell
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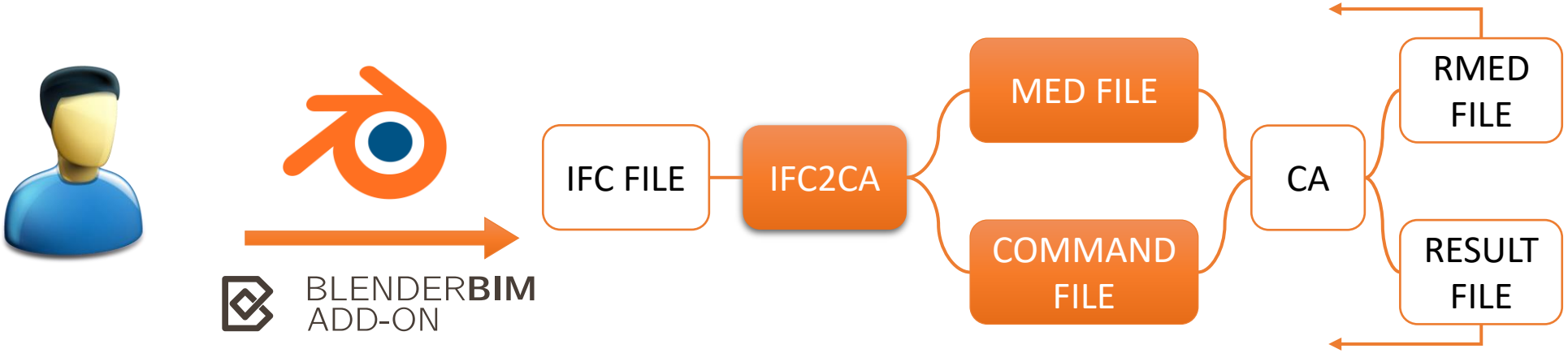
Structural Workflow with Code_Aster

- openBIM Structural Pipeline



IFC-To-Code_Aster

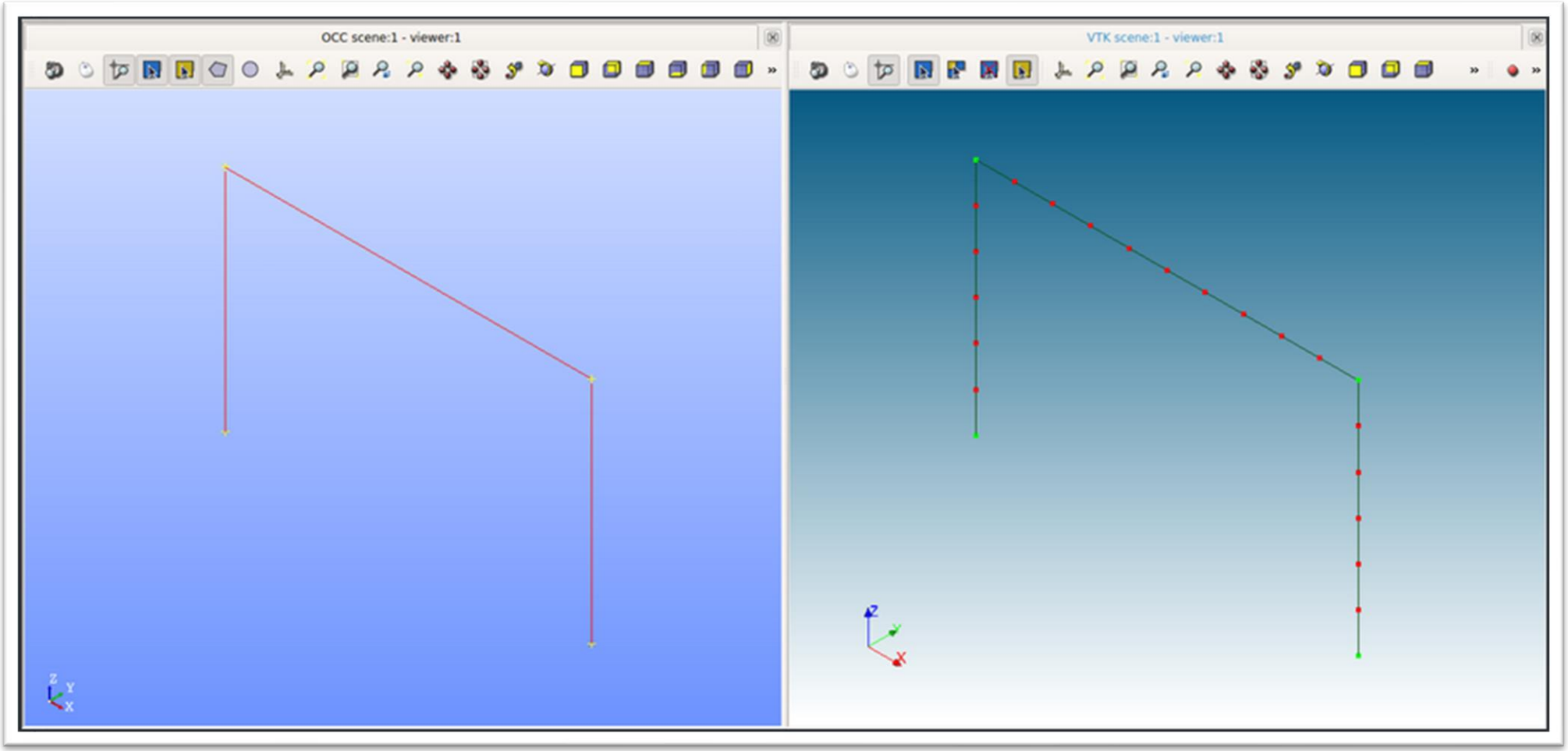
- Started in 2020 by **Ioannis Christovasilis**
- A static python script for Salome with a model-specific ifc-json file
- A model-specific command file for Code_Aster

MED FILE

COMMAND FILE

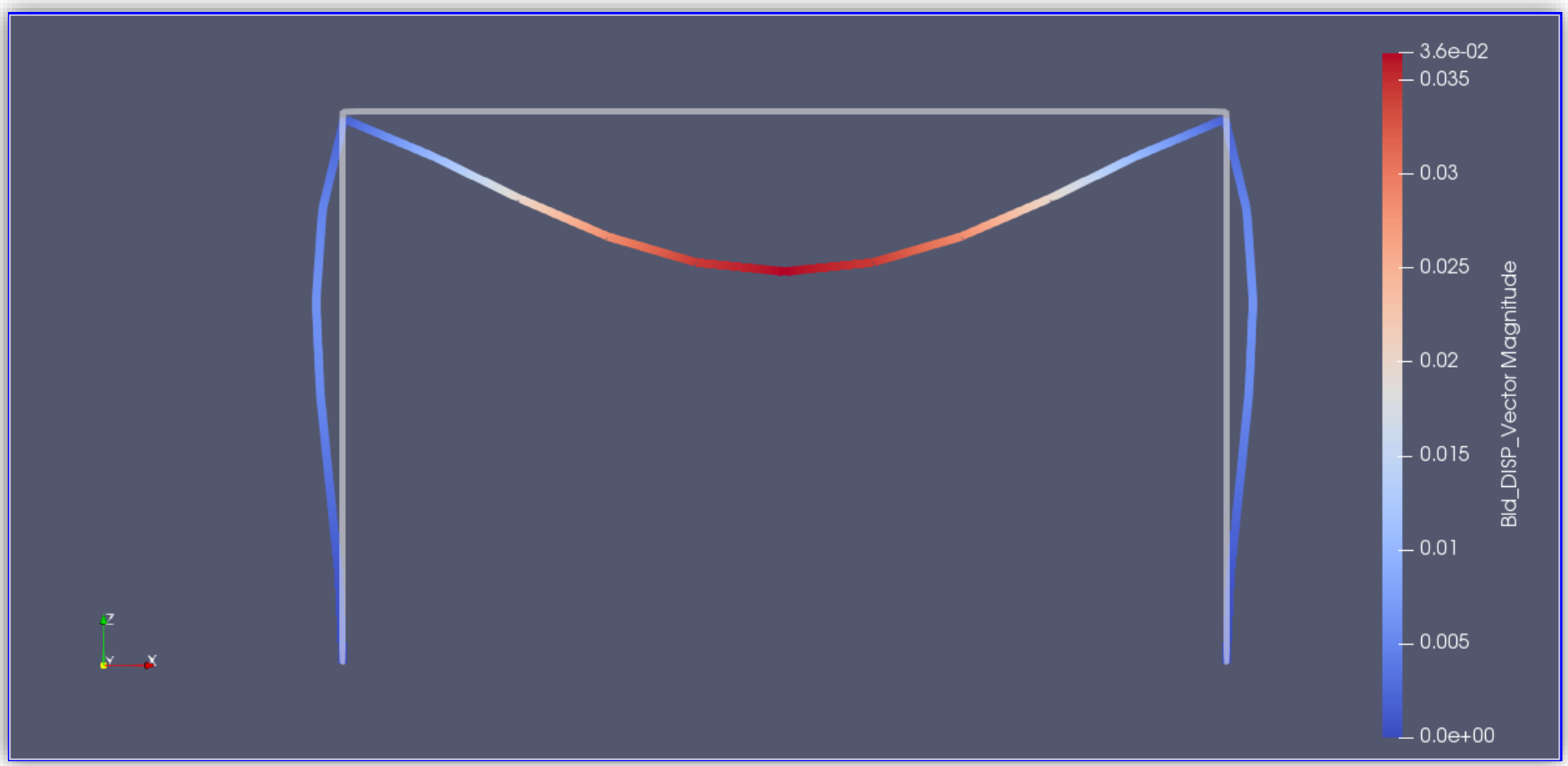
IFC-To-Code_Aster

Portal_01 Example



IFC-To-Code_Aster

Portal_01 Example



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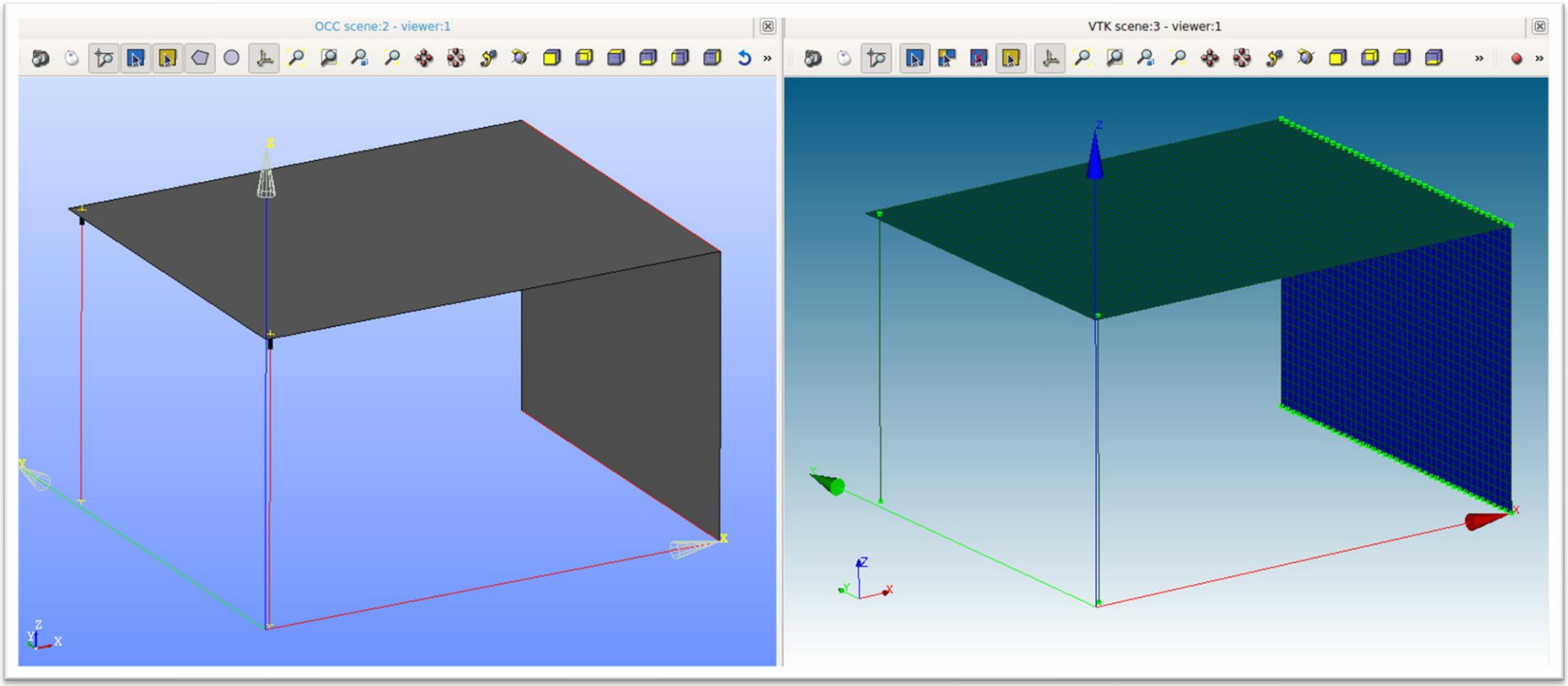
Structure_01 Example



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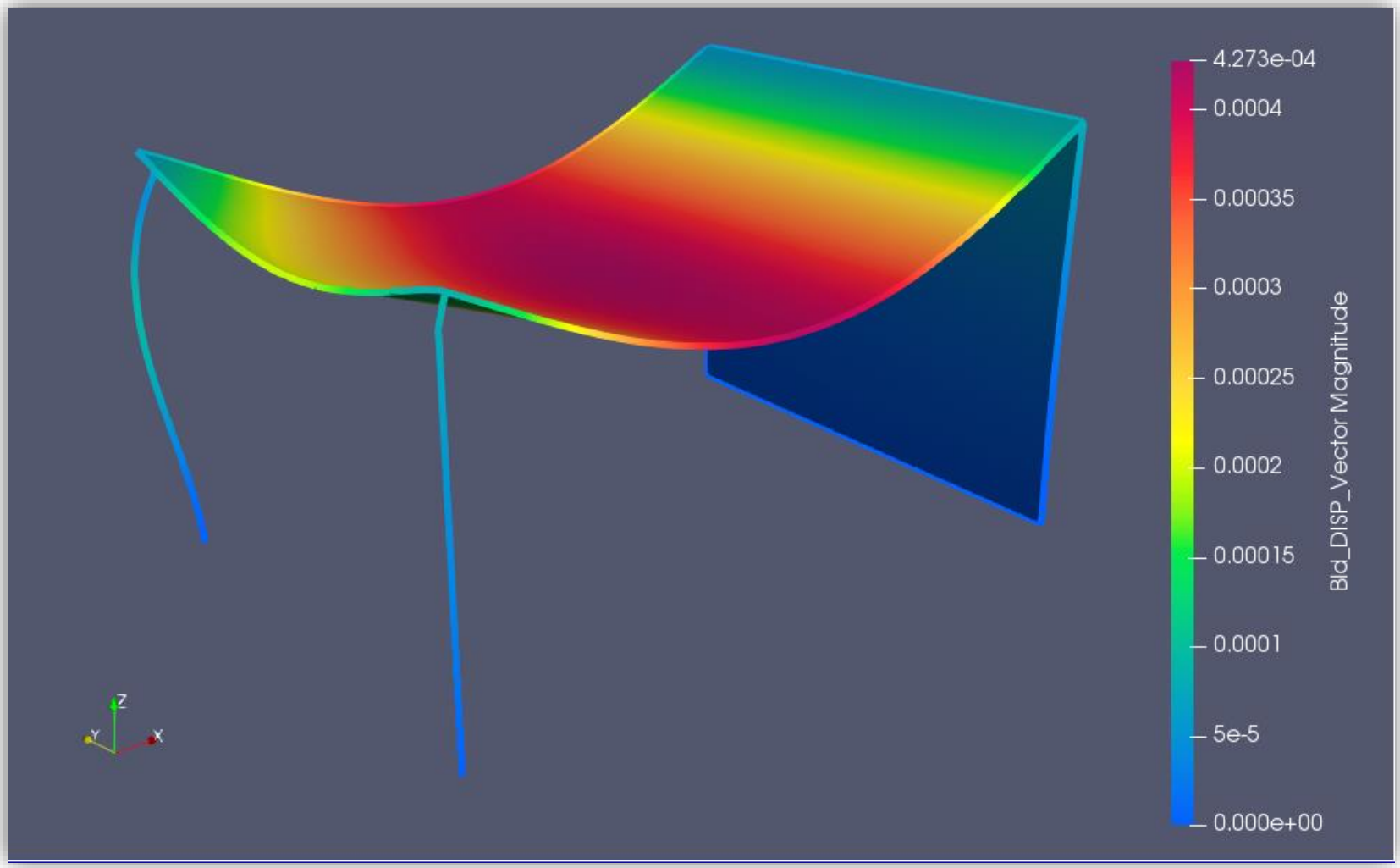
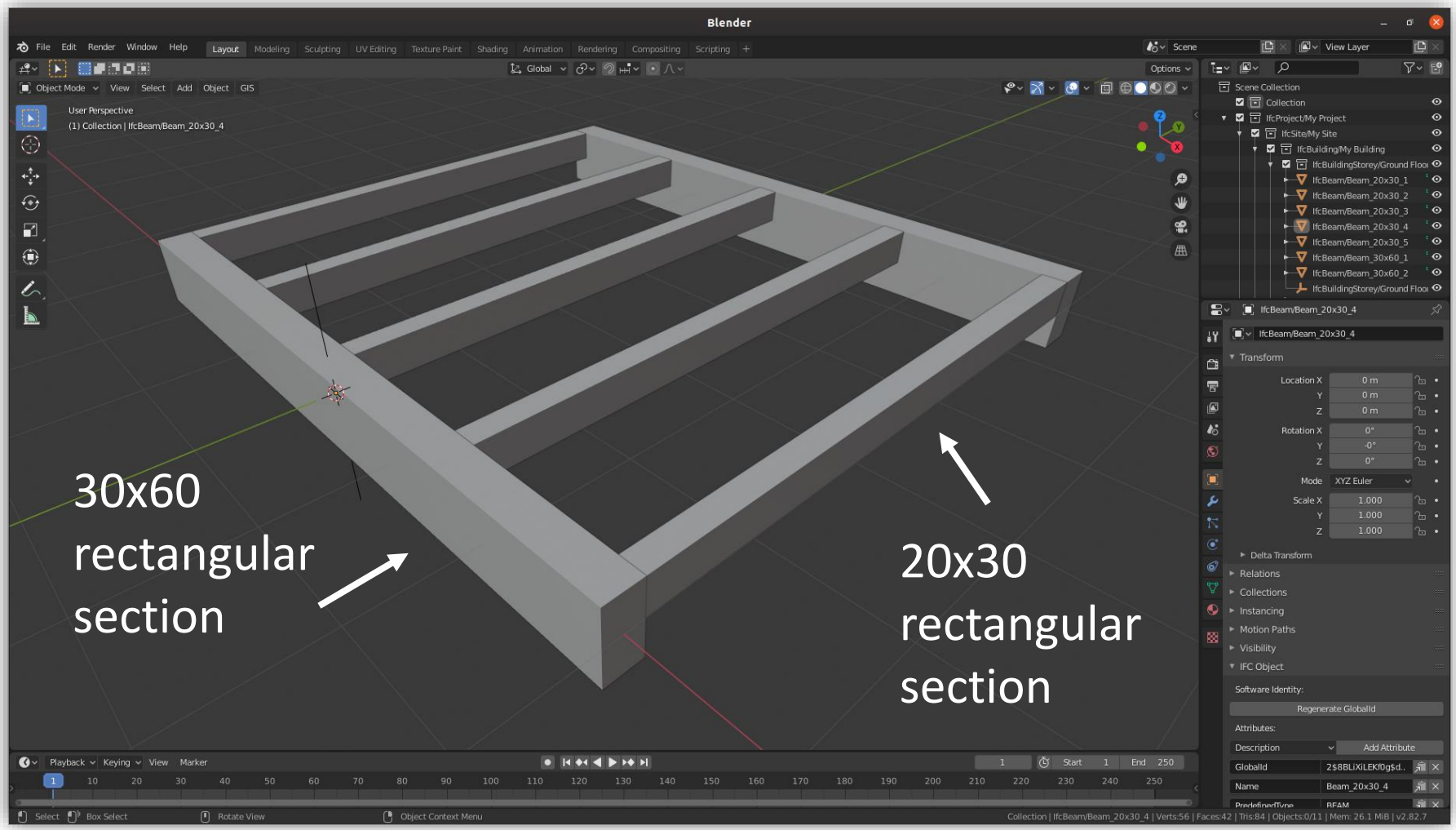
Structure_01 Example



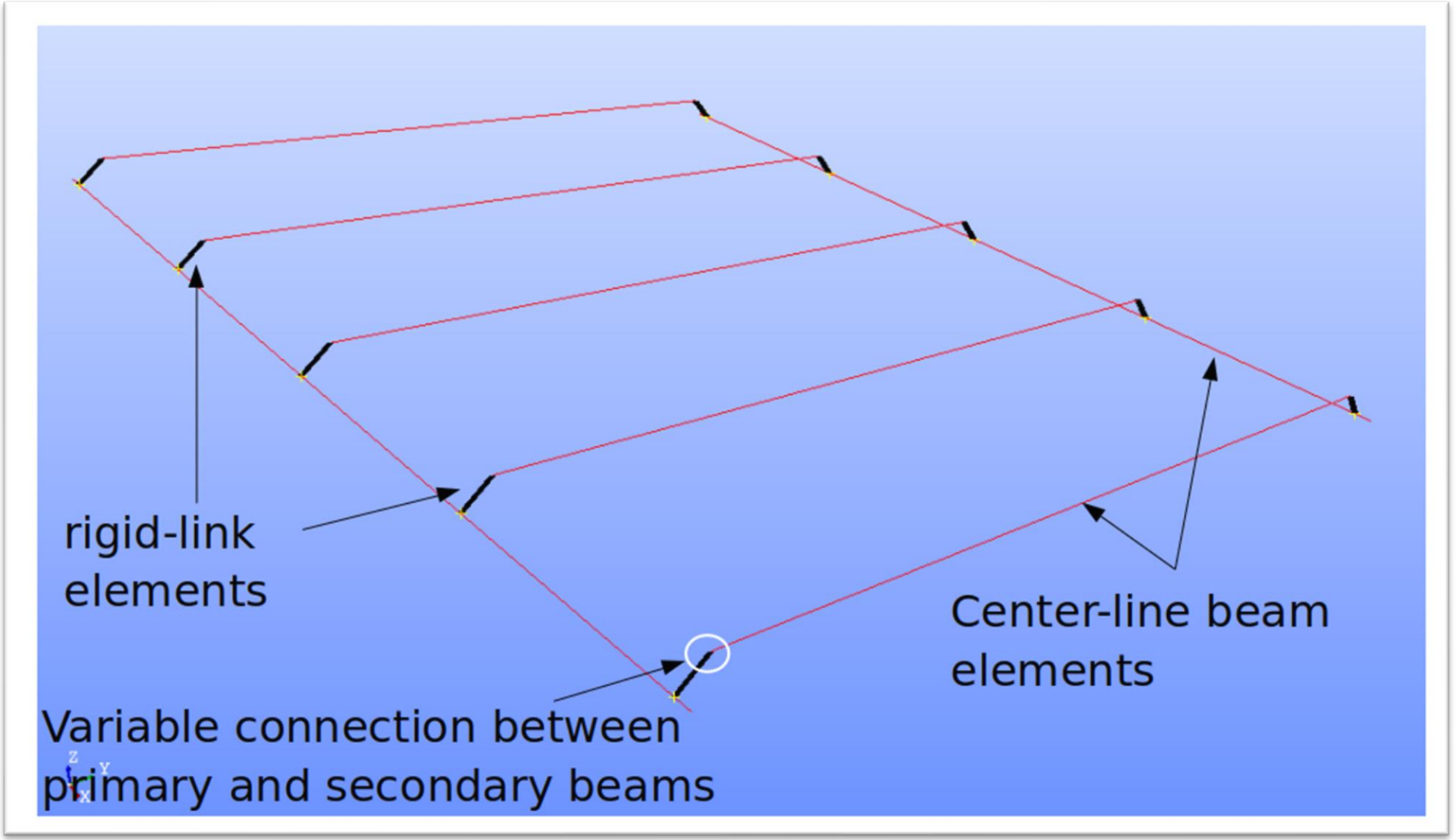
IFC-To-Code_Aster

Grid_of_beams Example



IFC-To-Code_Aster

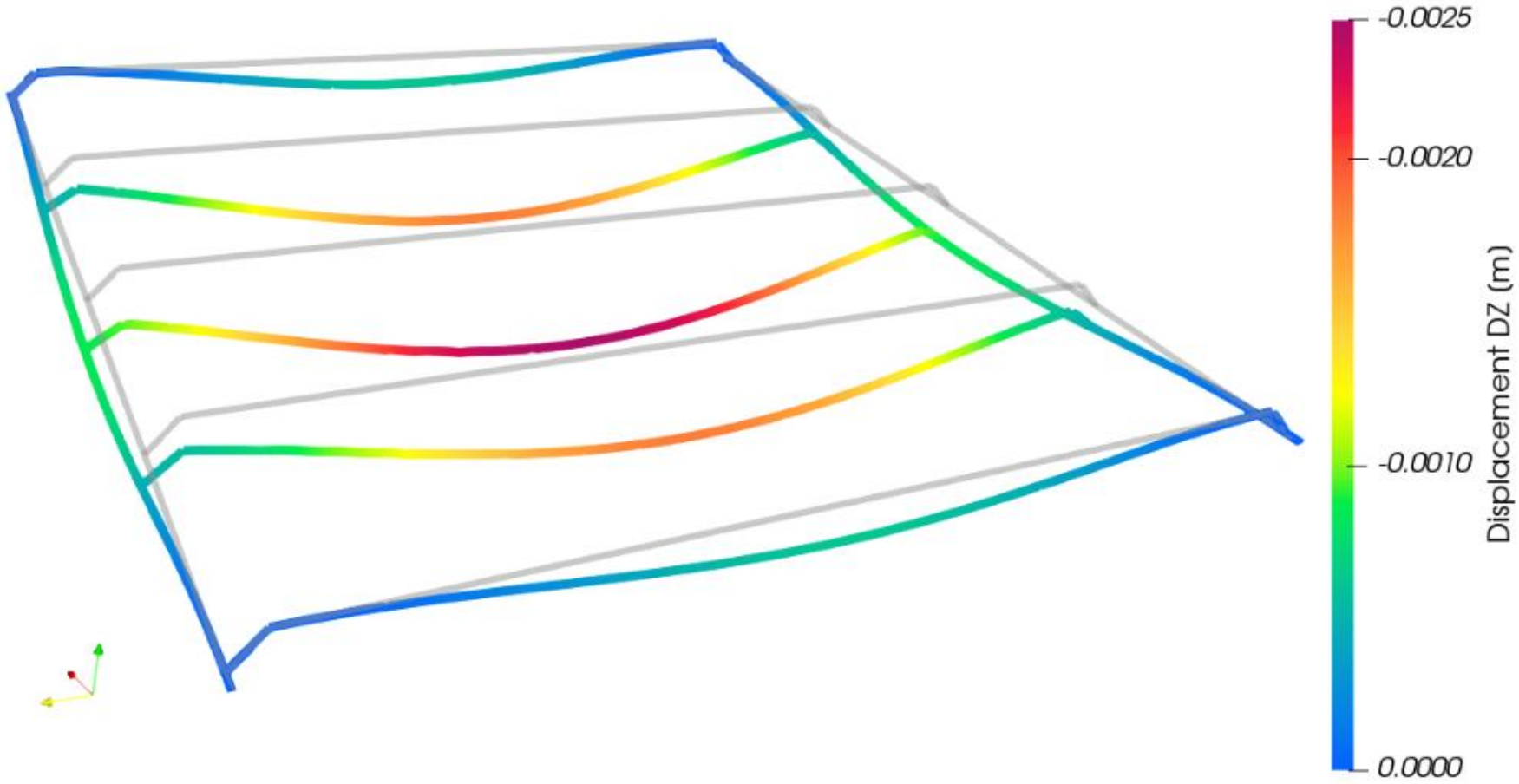
Grid_of_beams Example



IFC-To-Code_Aster

Grid_of_beams Example

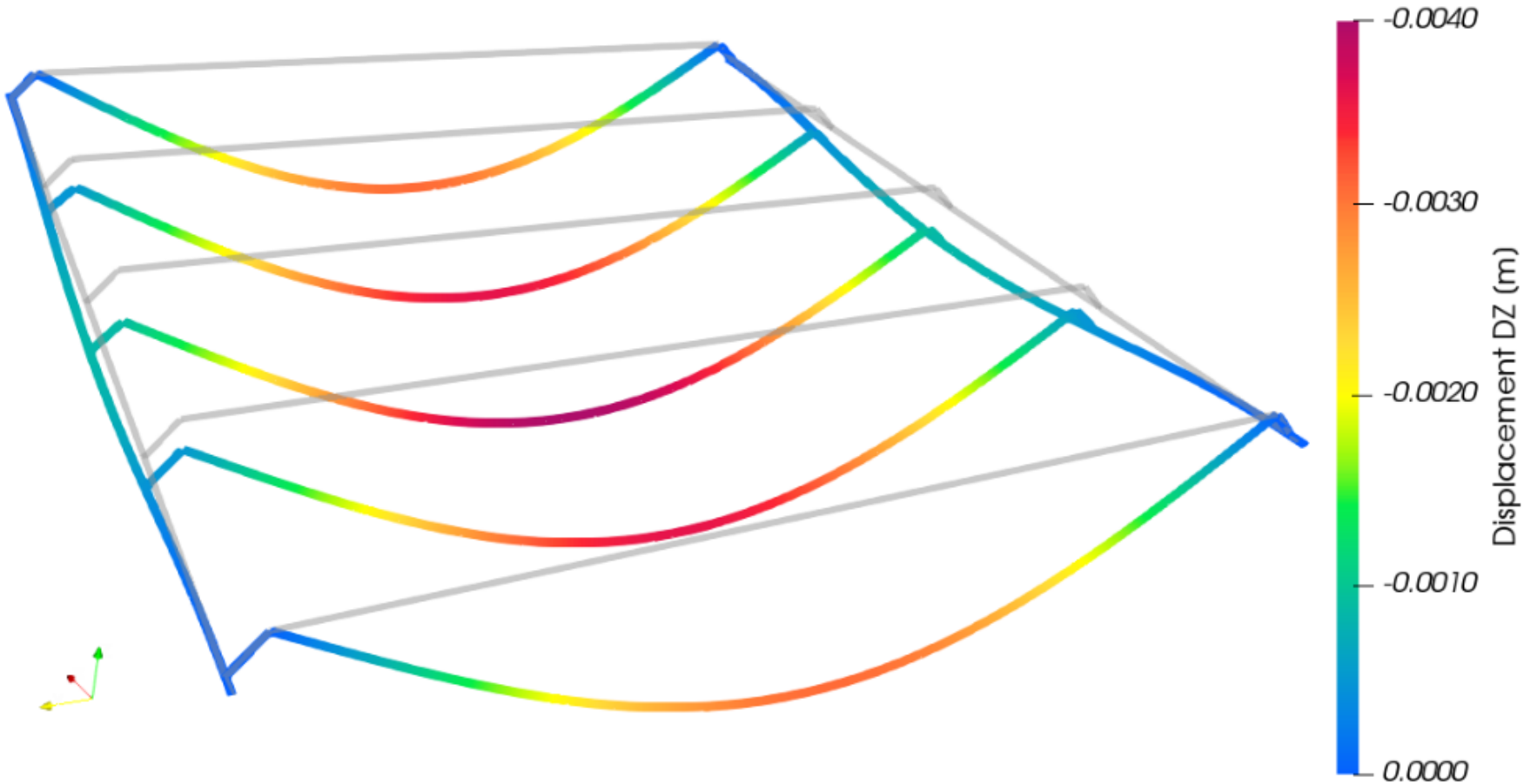
Fixed connections | dz_max = 2.5 mm



IFC-To-Code_Aster

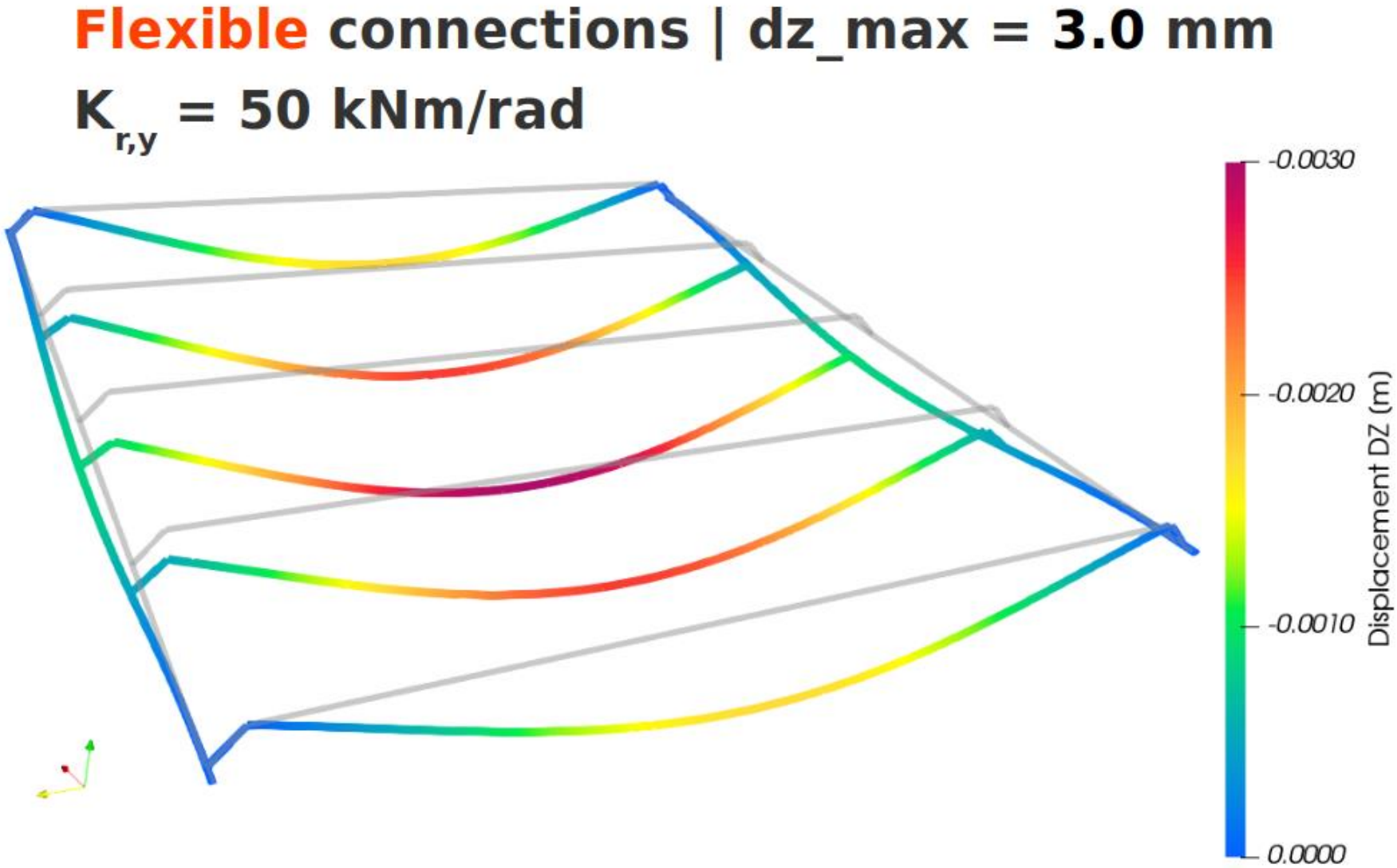
Grid_of_beams Example

Pinned connections | dz_max = 4.0 mm



IFC-To-Code_Aster

Grid_of_beams Example

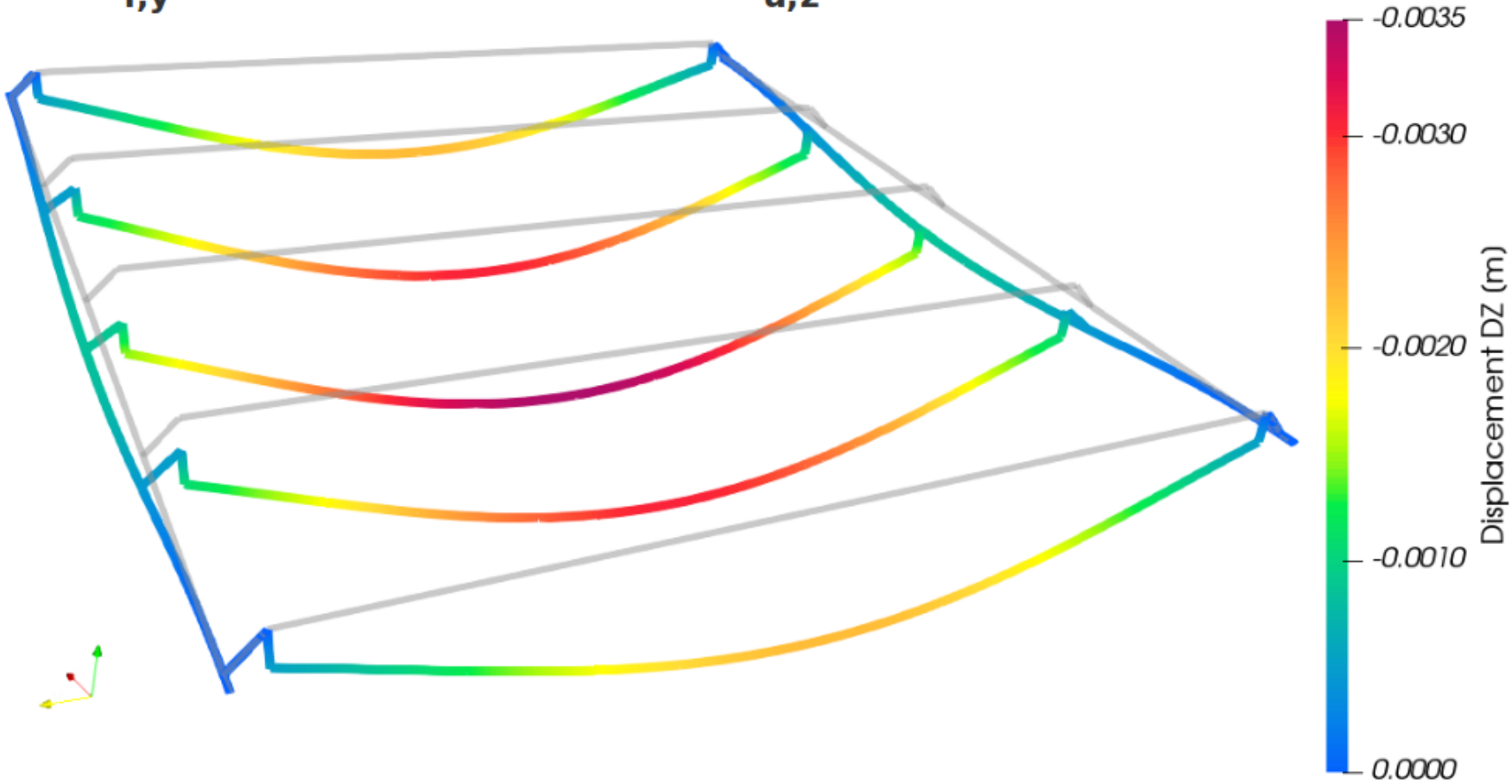


IFC-To-Code_Aster

Grid_of_beams Example

Flexible connections | dz_max = 3.5 mm

$K_{r,y}$ = 50 kNm/rad & $K_{u,z}$ = 200 kN/m



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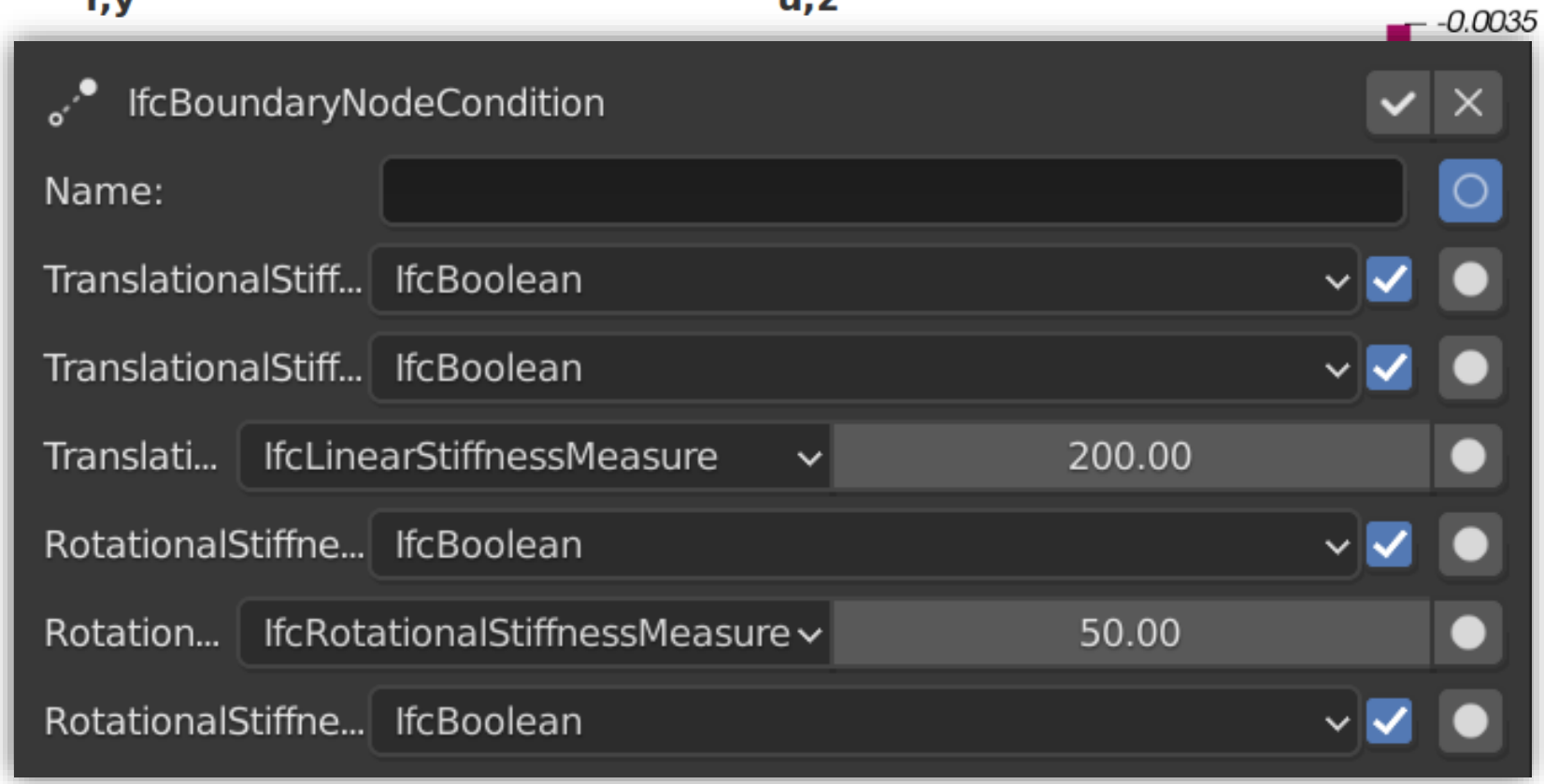

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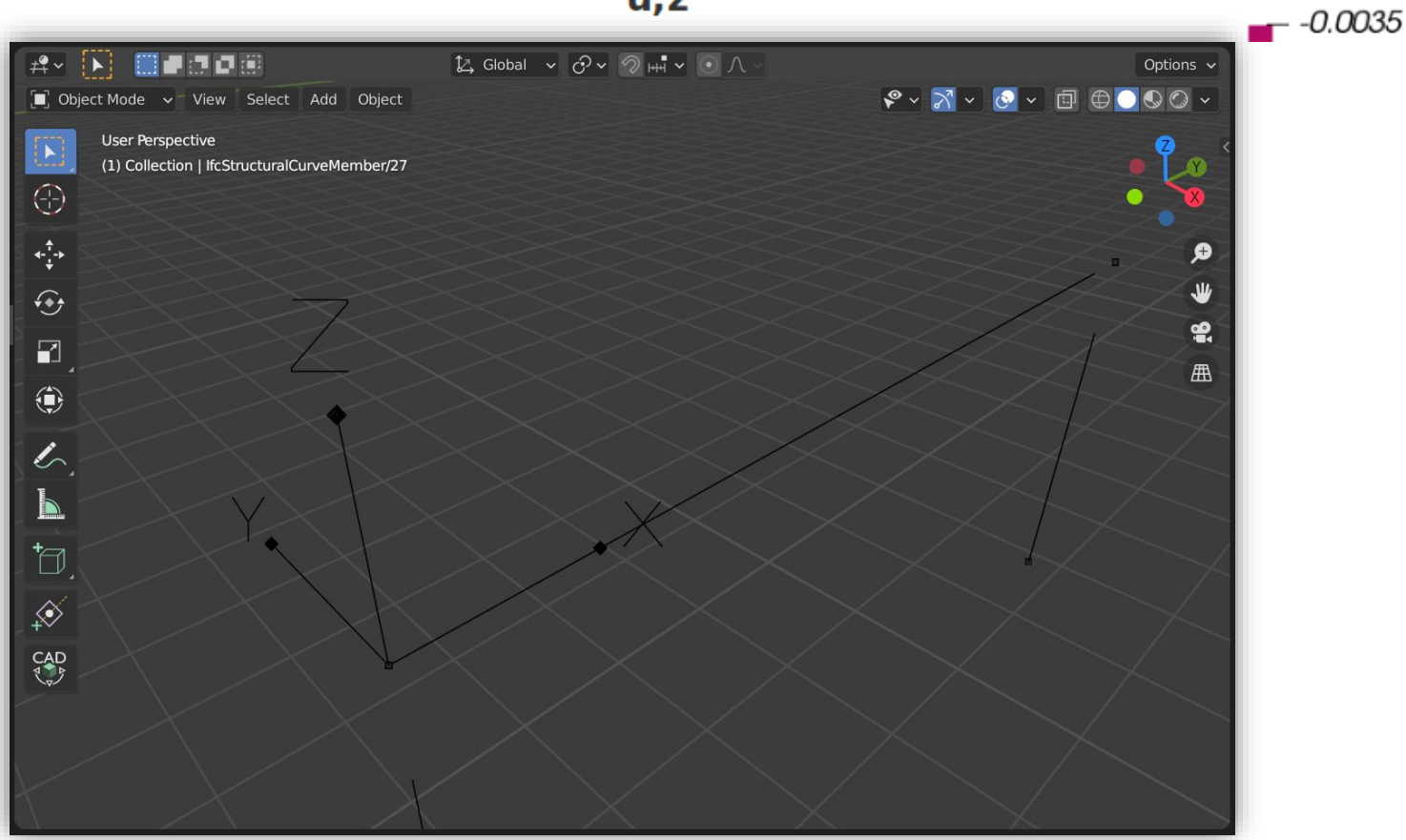
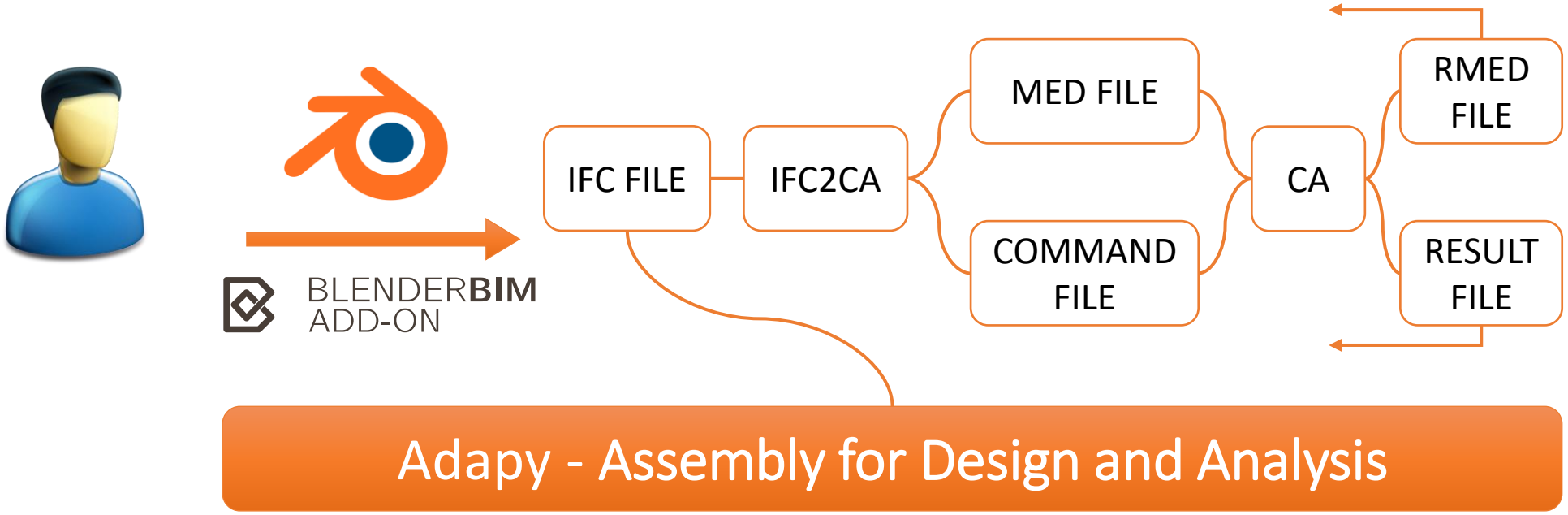


Structural Workflow with Code_Aster

- openBIM Structural Pipeline

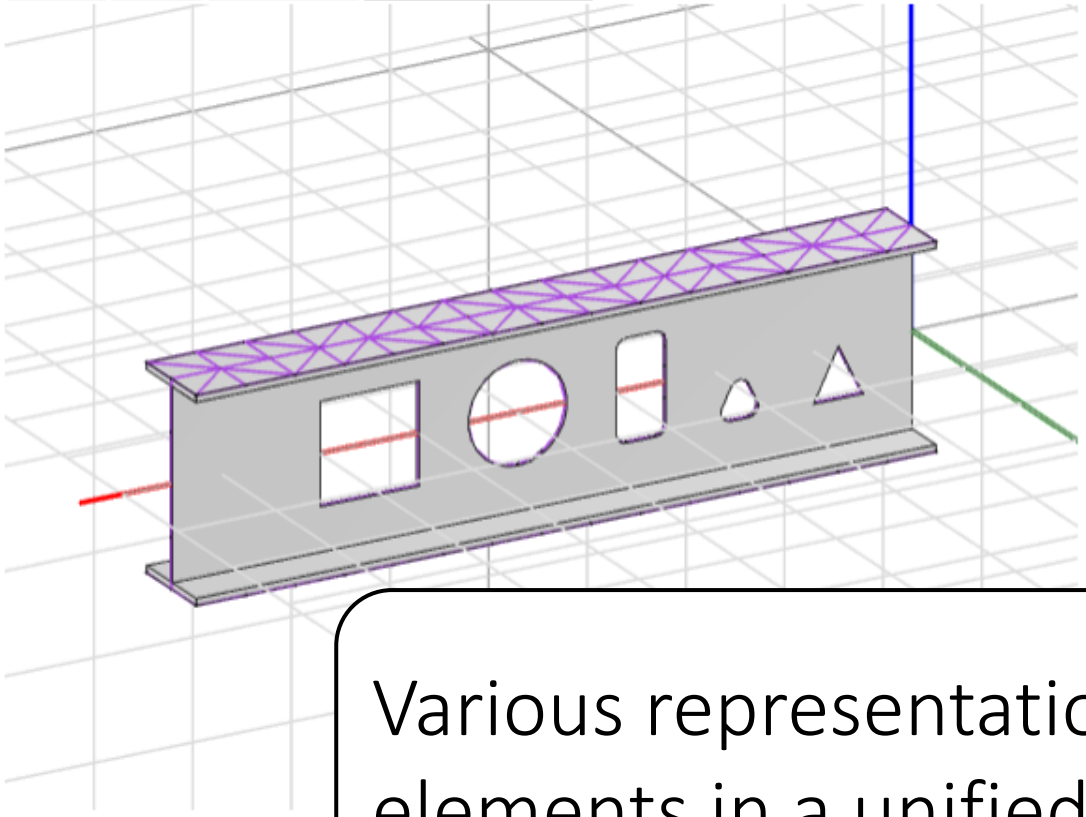


- Released in 2021 by **Kristoffer Andersen**
- A python package that focuses on interoperability between IFC and various Finite Element formats

Adapy - Assembly for Design and Analysis

```
In [2]: a = beam_ex1()
        a.to_ifc('../output/MyCantilever.ifc')
        a

step file created at "/home/adauser/temp/MyBeam_2Pc9KgkX4Hwx2CSbjQPXjX.stp"
ifc file created at "../output/MyCantilever.ifc"
```

Geom | Mesh | Reset View | Compute | None



Out[2]:

Various representations of structural elements in a unified way [1D, 2D, 3D]

Adapy - Assembly for Design and Analysis

Run a FEM analysis using Calculix

The Assembly method `to_fem` creates an analysis directory called "MyCantilever_calculix" inside the `scratch` directory.

By passing in `execute=True` calculix and code_aster will automatically start the analysis once the input files are created.

In [3]:
```
ccx_name = "MyCantilever_calculix"
a.to_fem(ccx_name, "calculix", overwrite=True, execute=True)
```

```
Exporting to "calculix" using to_fem
Created a Calculix input deck at "/home/adauser/scratch/MyCantilever_calculix"
------------------------------------------------------------------------------
starting Calculix simulation "MyCantilever_calculix" (on Linux)
Finished Calculix simulation "MyCantilever_calculix"
------------------------------------------------------------------------------
```

Run a FEM analysis using Code Aster

In [4]:
```
ca_name = "MyCantilever_code_aster"
a.to_fem(ca_name, "code_aster", overwrite=True, execute=True)
```

```
Exporting to "code_aster" using to_fem
creating: MyCantilever_code_aster
Removing old f
Created a Code
--------------
starting CodeA
Finished CodeA
--------------
```

Commercial and OS solvers in a unified way
[CalculiX, Code_Aster, Abaqus, Sesam]

Adapy - Assembly for Design and Analysis

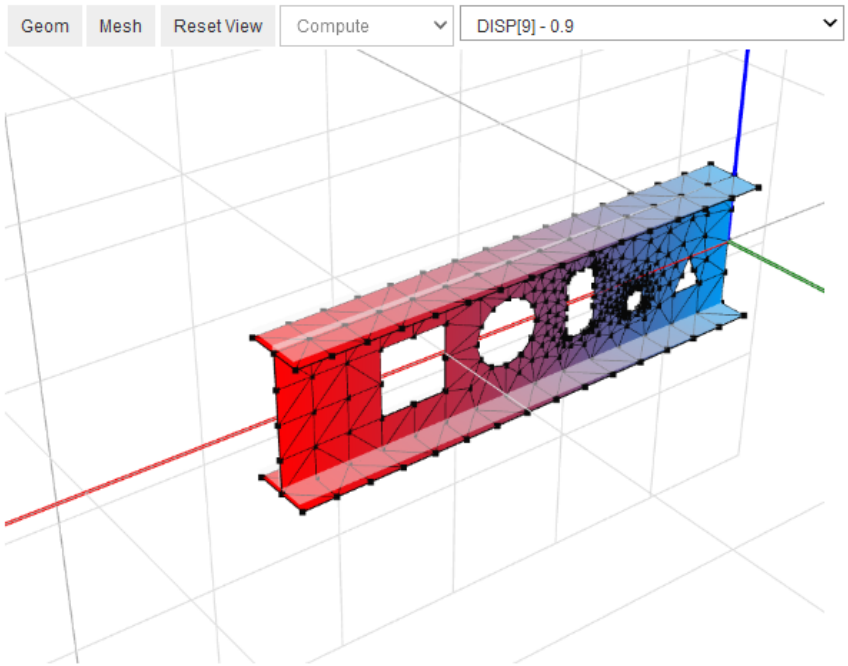
In [1]:
```
from ada.param_models.fem_models import beam_ex1
from ada.config import Settings

Settings.return_experimental_fem_res_after_execute = True
```

In [2]:
```
a = beam_ex1()
res = a.to_fem("MyCantilever_code_aster", "code_aster", overwrite=True, execute=True)
```

```
step file created at "/home/adauser/temp/MyBeam_29LguokX0HwuqwSbjQPXjX.stp"
Exporting to "code_aster" using to_fem
creating: MyCantilever_code_aster
Created a Code_Aster input deck at "/home/adauser/scratch/MyCantilever_code_aster"
--------------------------------------------------------------------------------
starting CodeAsterAnalysis simulation "MyCantilever_code_aster" (on Linux)
Finished CodeAsterAnalysis simulation "MyCantilever_code_aster"
--------------------------------------------------------------------------------
```

In [3]:
```
res
```

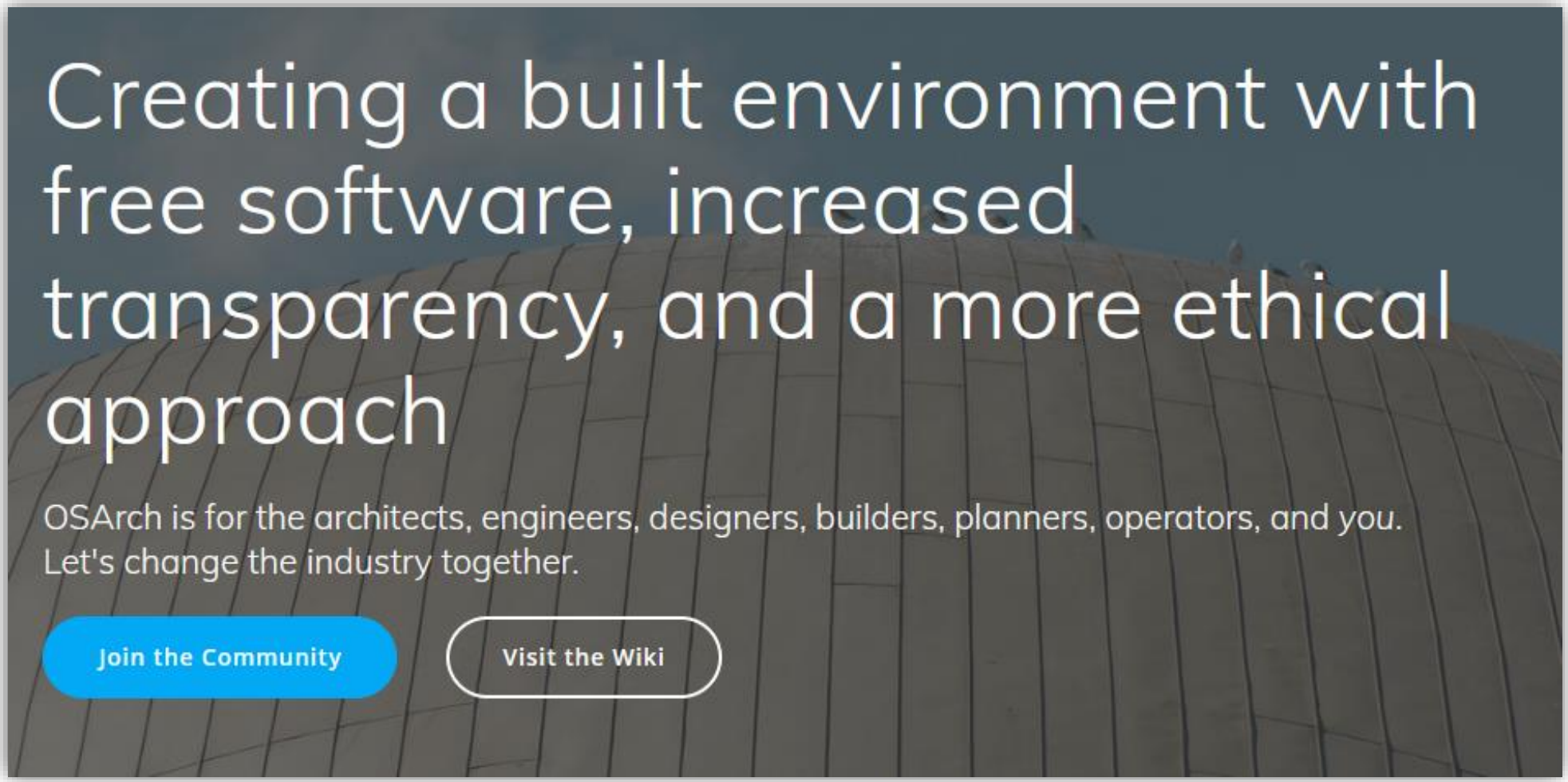
```
Changed field value to "DISP[9] - 0.9"
```



Docker container and use with Jupyter Notebook

OSArch Organisation

Website - osarch.org



OSArch Organisation

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We help create the built environment with free software, increased transparency, and a more ethical approach.

On this wiki, we collect and share everything we know about the free technology in our industry. Every page on this website was written by people just like you.

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- See more ways to contribute to OSArch

Explore Free Software edit

Did you know there's a growing list of over 100 free tools to help you do your job? Unlike proprietary software, free software will never make your digital work incompatible, obsolete, or force you into subscriptions. See the AECO Free Software Directory.

Begin your journey:

- Switch to QCAD and LibreCAD for 2D CAD drafting instead of depending on AutoCAD
- Learn OpenBIM authoring with the BlenderBIM Add-on
- Learn solid 3D modeling and BIM model creation with FreeCAD

Use Open Standards edit

Open technology and standards helps our digital tools interoperate and protect you against data expiry. See what's available at the Open Data Standards Directory.

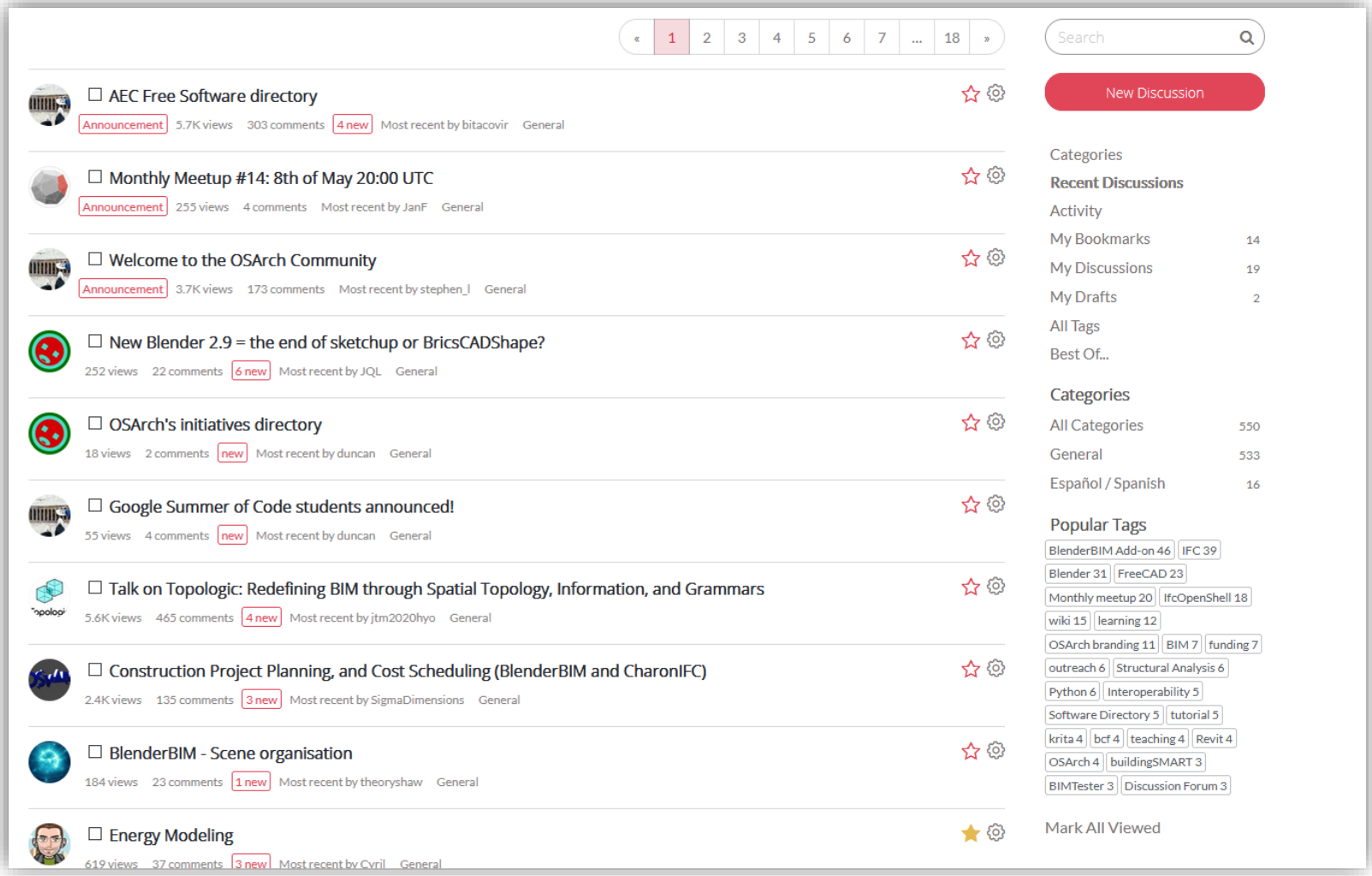
- Learn about OpenBIM
- Get sample files of Open Data
- Learn about relevant Standards organizations
- Read Academic Papers and external articles

Learn about Industry Foundation Class (IFC) data concepts:

- An introduction to IFC
- What is an IFC class

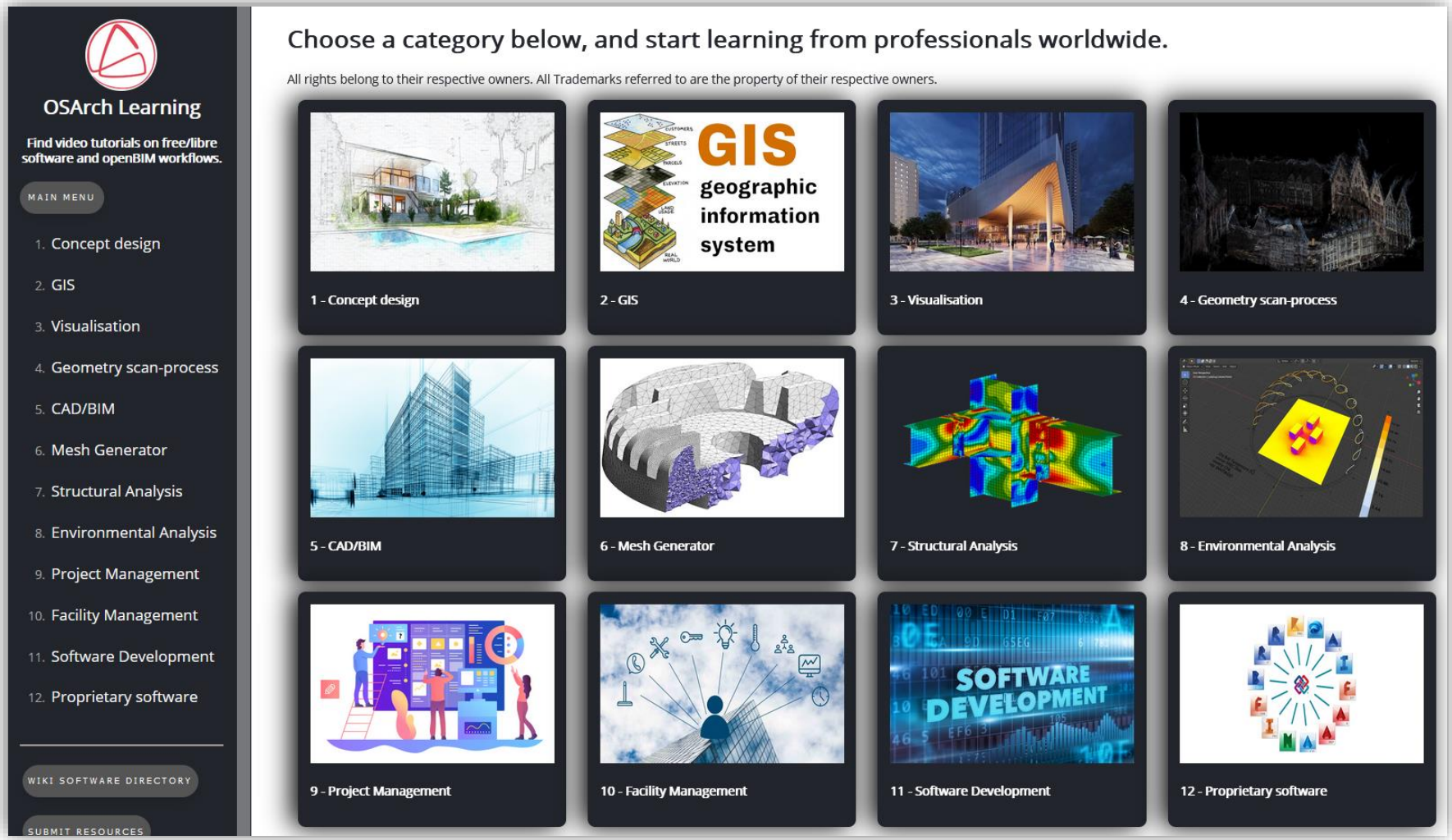
OSArch Organisation

Community - community.osarch.org



OSArch Organisation

Learning - learn.osarch.org



Thank you!

- BlenderBIM: https://blenderbim.org/
- IfcOpenShell: https://github.com/IfcOpenShell/IfcOpenShell
- adapy: https://github.com/Krande/adapy
- OSArch: https://osarch.org/

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