

IFC-Driven Code_Aster Analyses for Buildings

Ioannis P. Christovasilis
Lorenzo Riparbelli



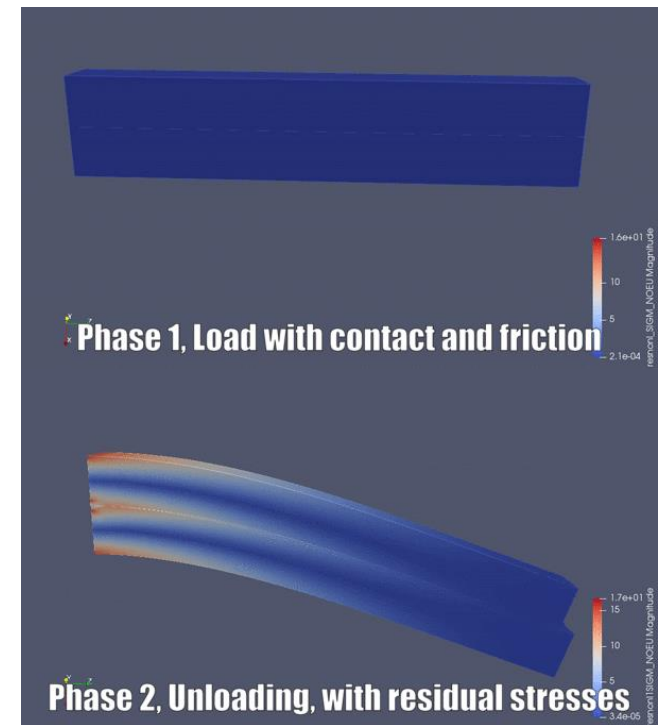
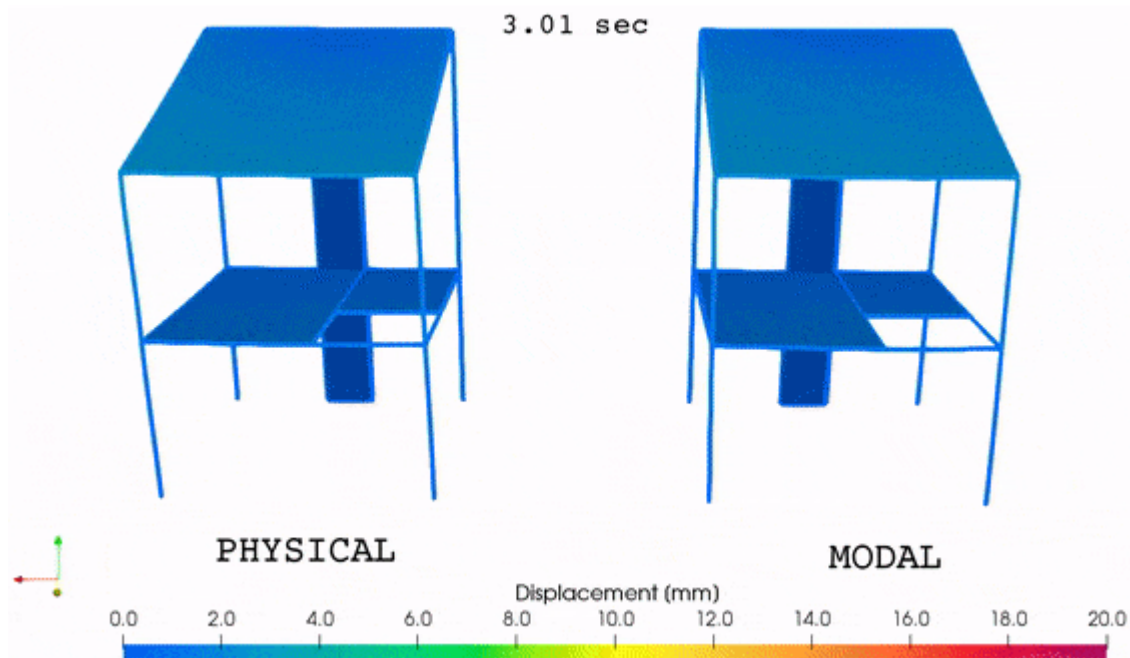
ProNET Meeting
May 20, 2021



Aether Engineering



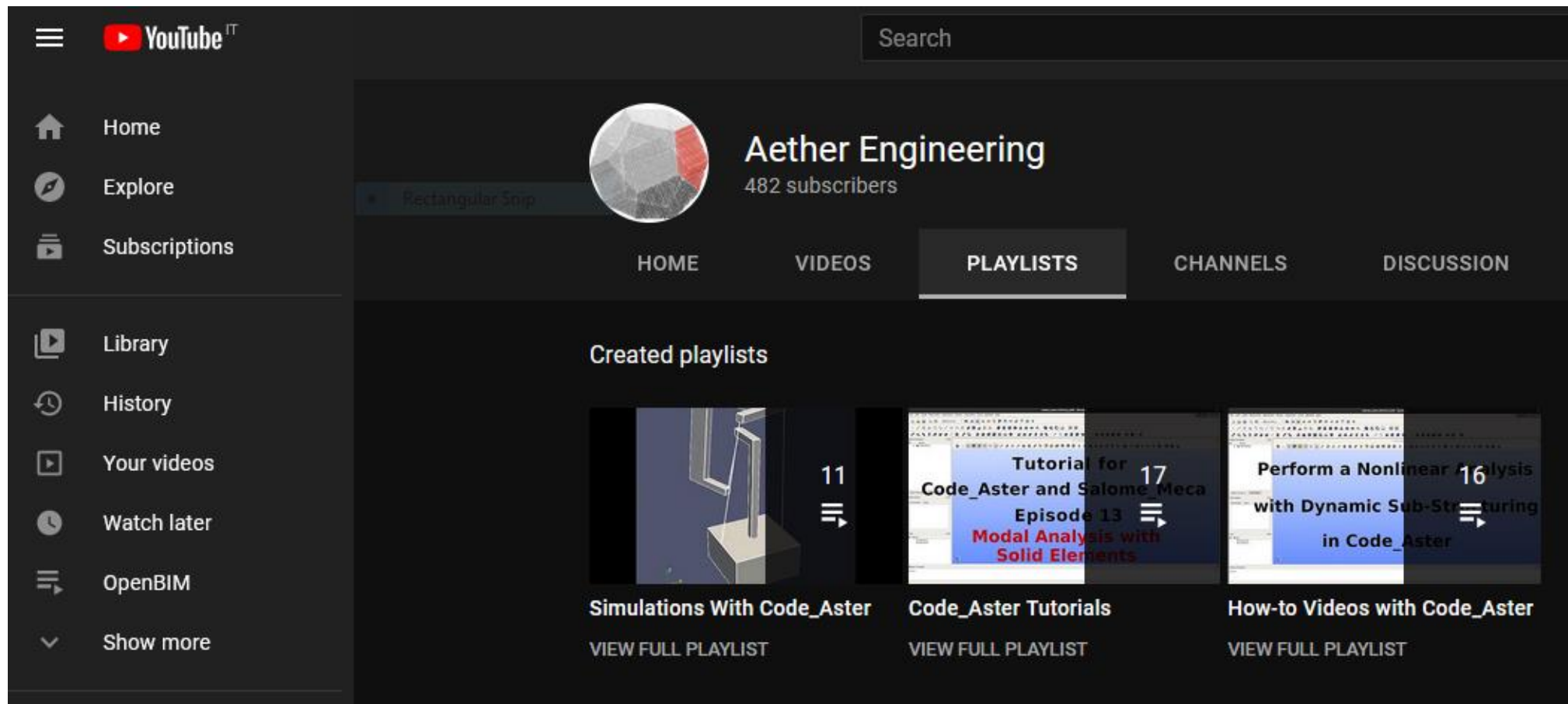
- Engineering & Software Company in Florence, IT
- Code_Aster users from day 1 (> 5 years)
- Structural - Civil and Mechanical Sector



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

A screenshot of the GitHub repository page for "Jesusbill / code-aster-examples". The interface is in dark mode. At the top, there's a search bar and navigation links for Pulls, Issues, Marketplace, and Explore. The repository name is "Jesusbill / code-aster-examples" with 8 watchers, 35 stars, and 15 forks. Below this are tabs for Code, Issues, Pull requests, Actions, Projects, Wiki, Security, and Insights. The "Code" tab is selected. Under the "Code" tab, there's a dropdown for the "master" branch, buttons for "Go to file", "Add file", and a green "Code" button. To the right is an "About" section with a description: "A number of examples for Code_Aster and Salome_Meca", and links for "Readme" and "View license". Below the "Code" button, there's a list of files and folders:

File/Folder	Load Examples	Last Updated
CompositeShellExample	load examples	12 months ago
CustomBeamProfile	load examples	12 months ago
DefineLocalAxes1D	load examples	12 months ago

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:



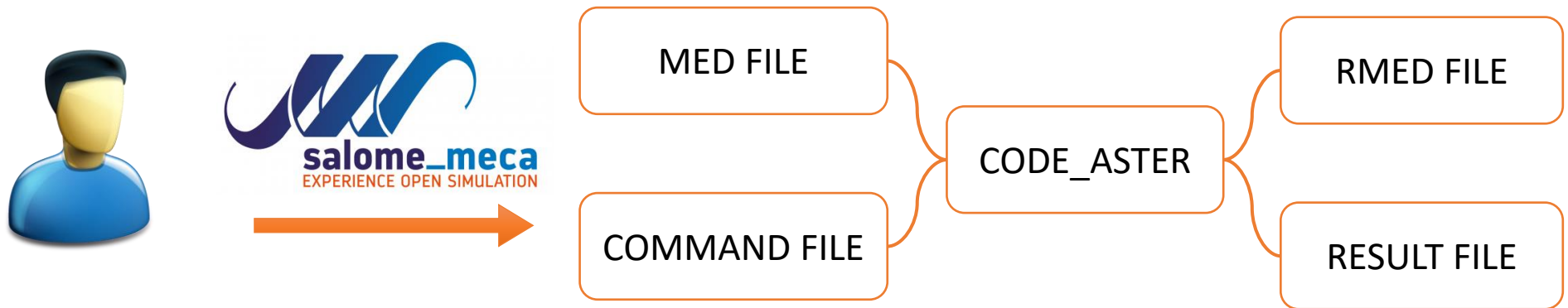
- Developed by buildingSMART International (bSI)
- Provides a complete set of data models for the description of building assets in all needed disciplines of the Architecture, Engineering and Construction (AEC) Sector
- It includes entities specific for Structural Analysis!!

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

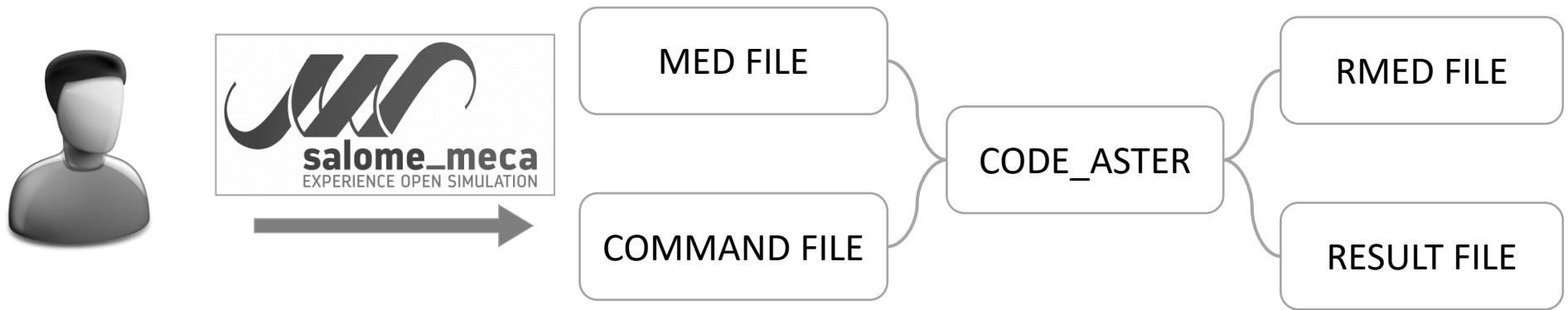
Structural Workflow with Code_Aster

- Traditional FEM Pipeline

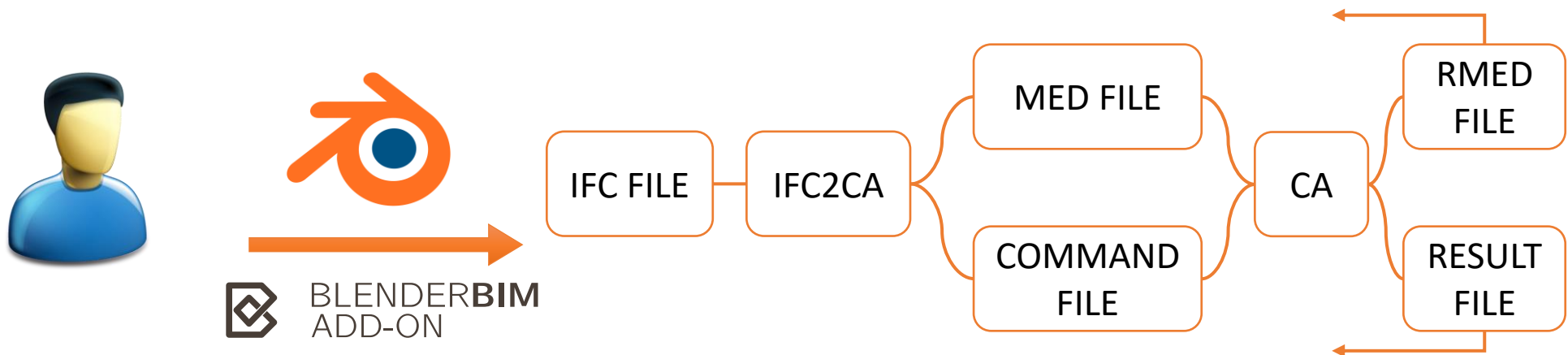


Structural Workflow with Code_Aster

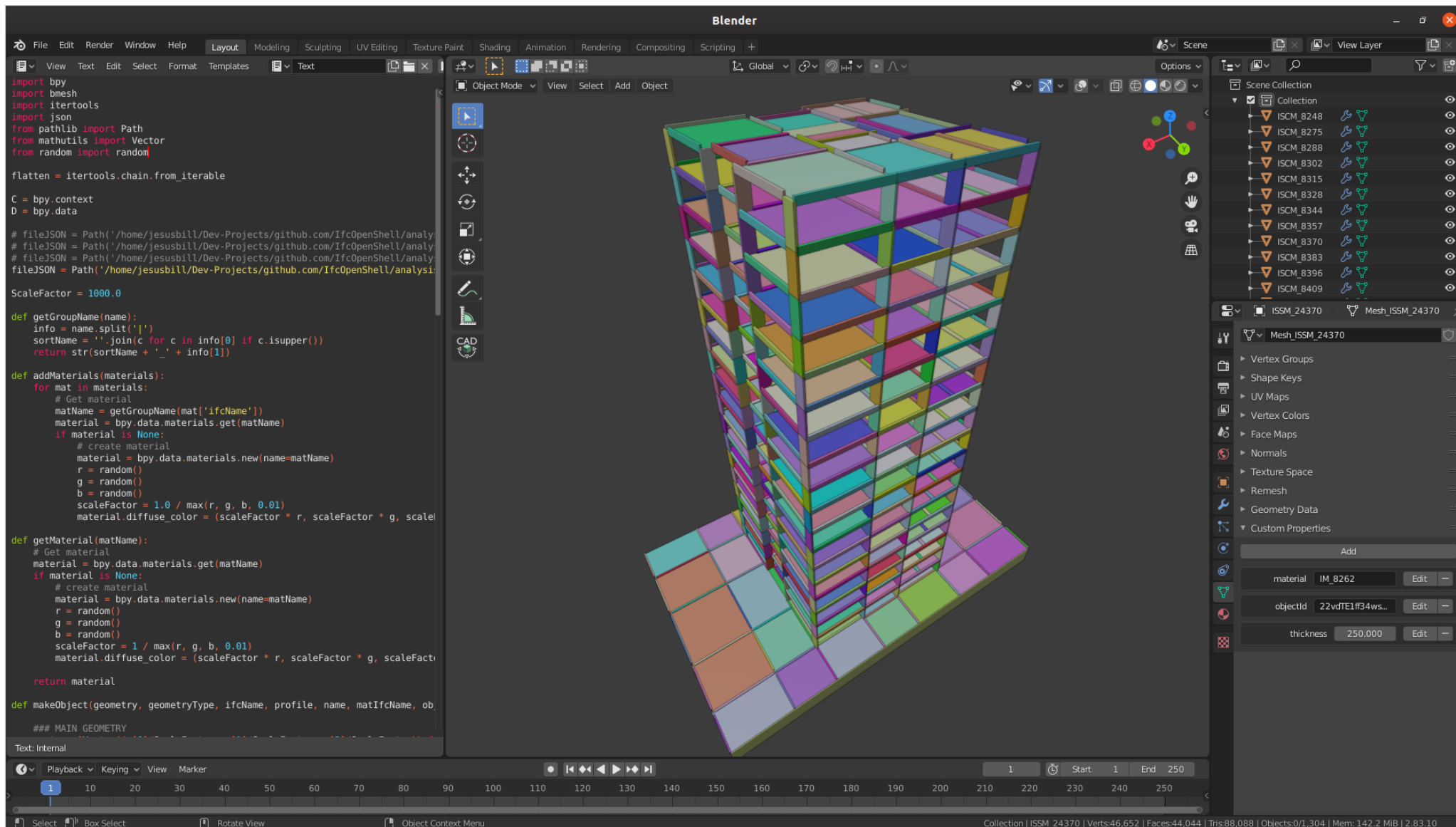
- Traditional FEM Pipeline



- openBIM Structural Pipeline

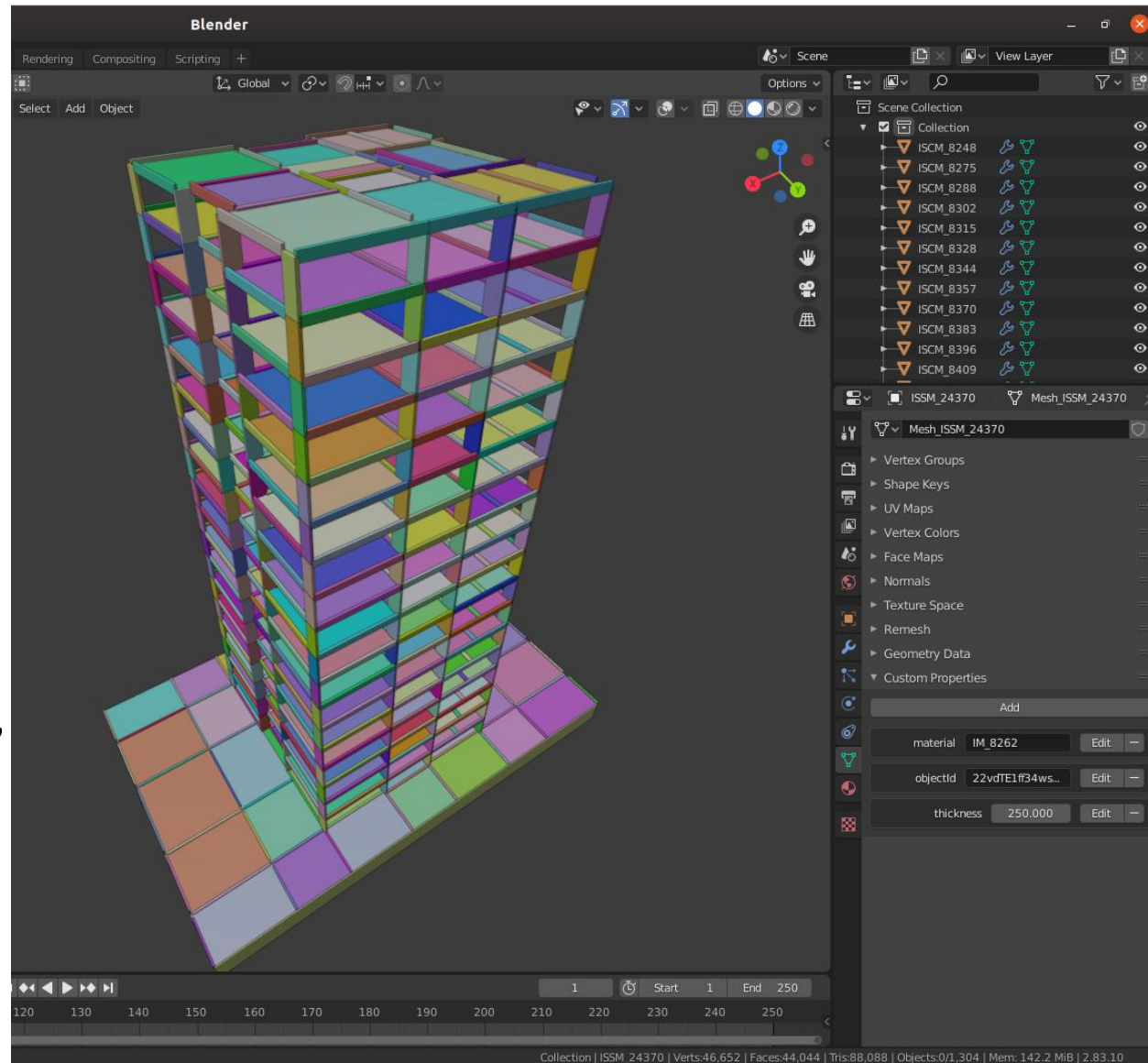


Blender and the BlenderBIM Add-On

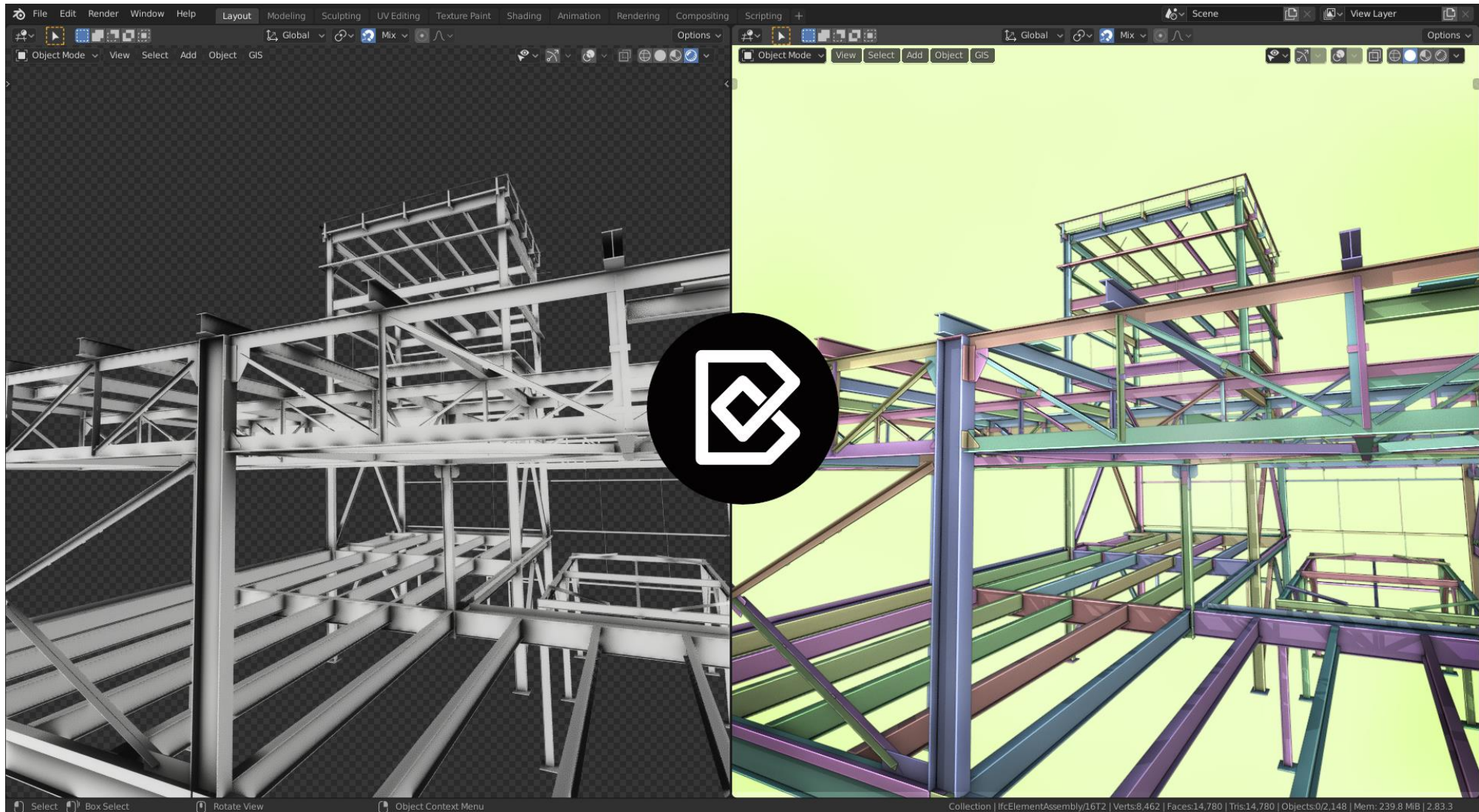


Blender and the BlenderBIM Add-On

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



Blender and the BlenderBIM Add-On



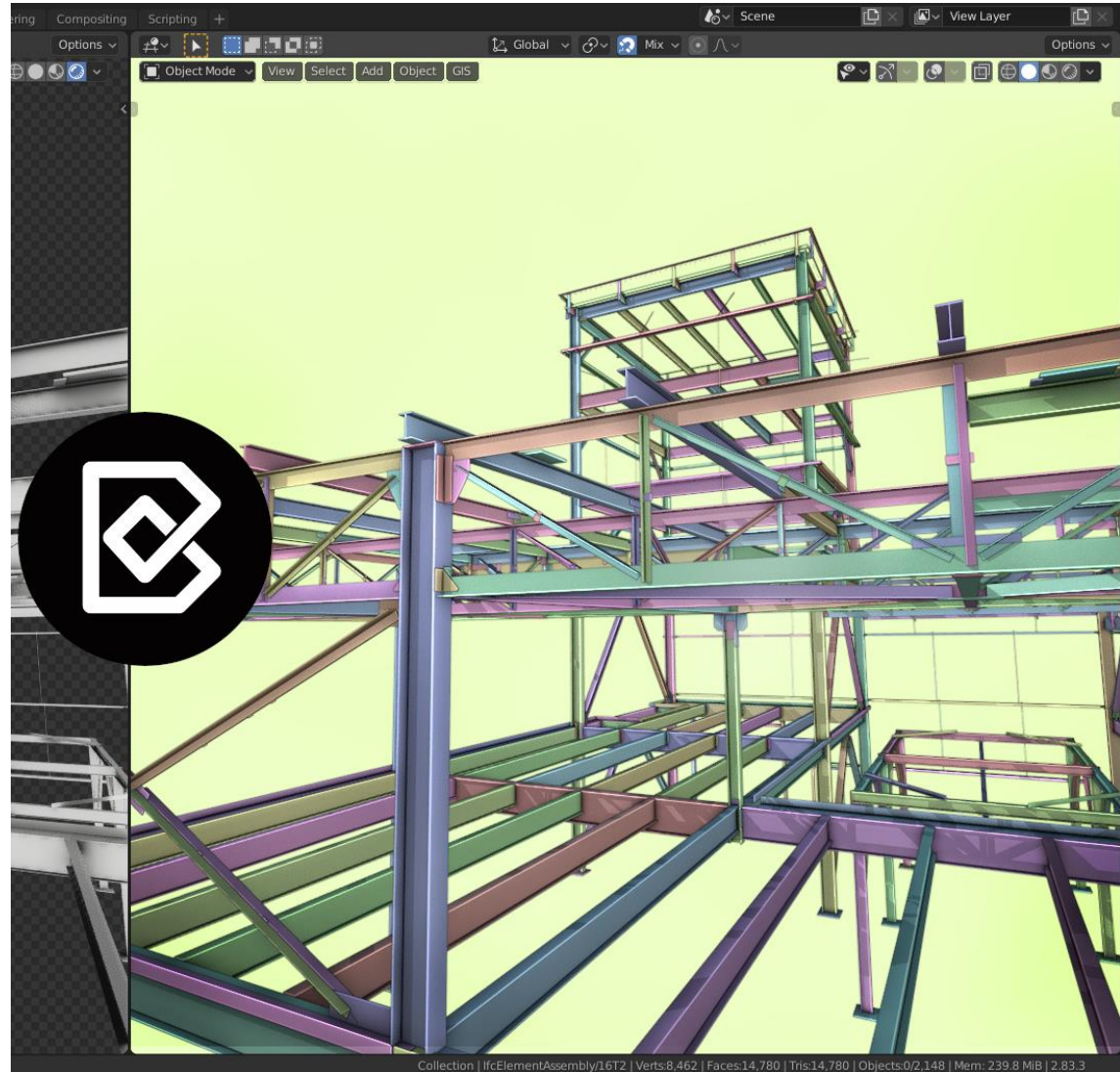
Blender and the BlenderBIM Add-On

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

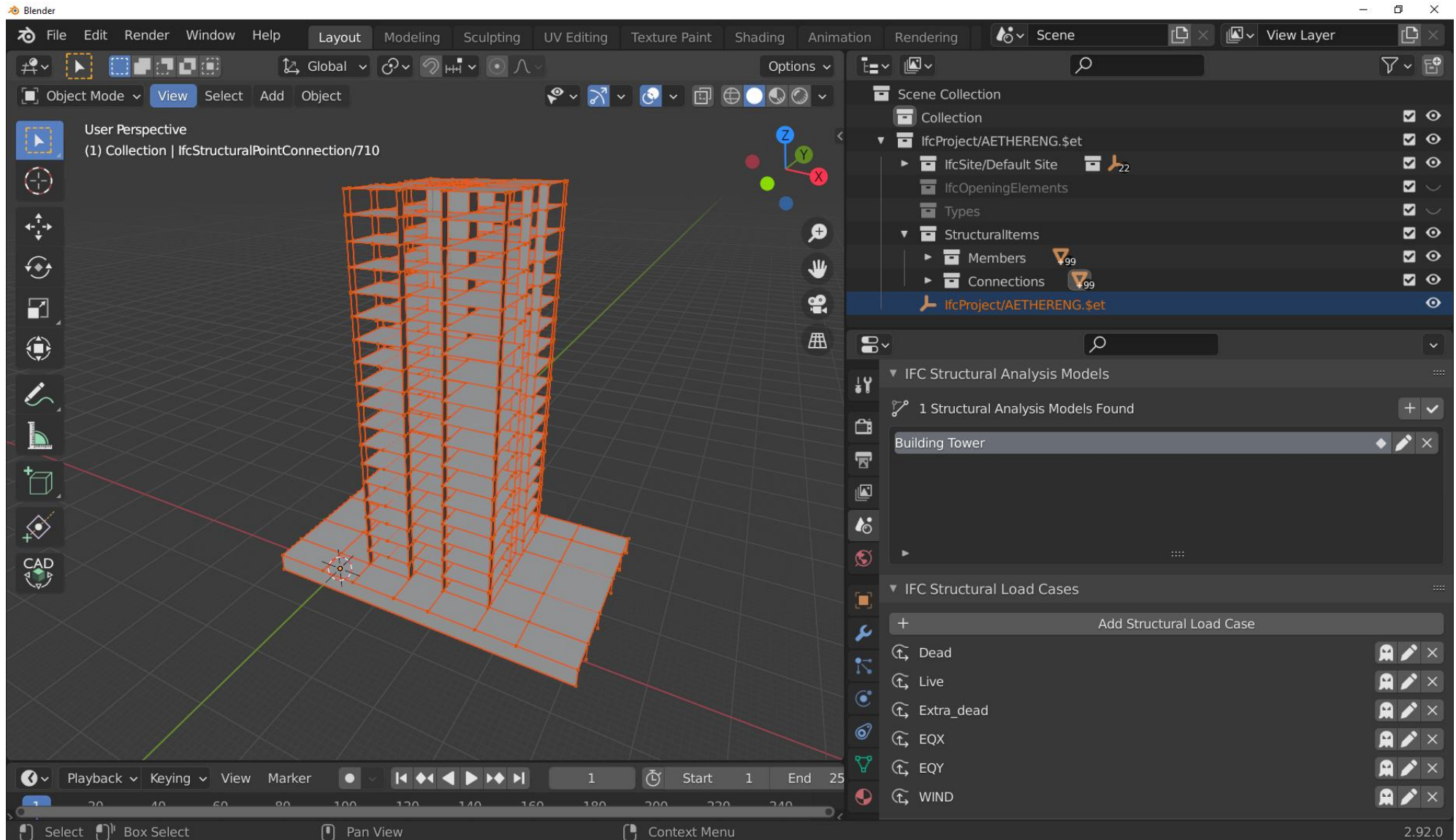


IfcOpenShell

the open source ifc toolkit and geometry engine

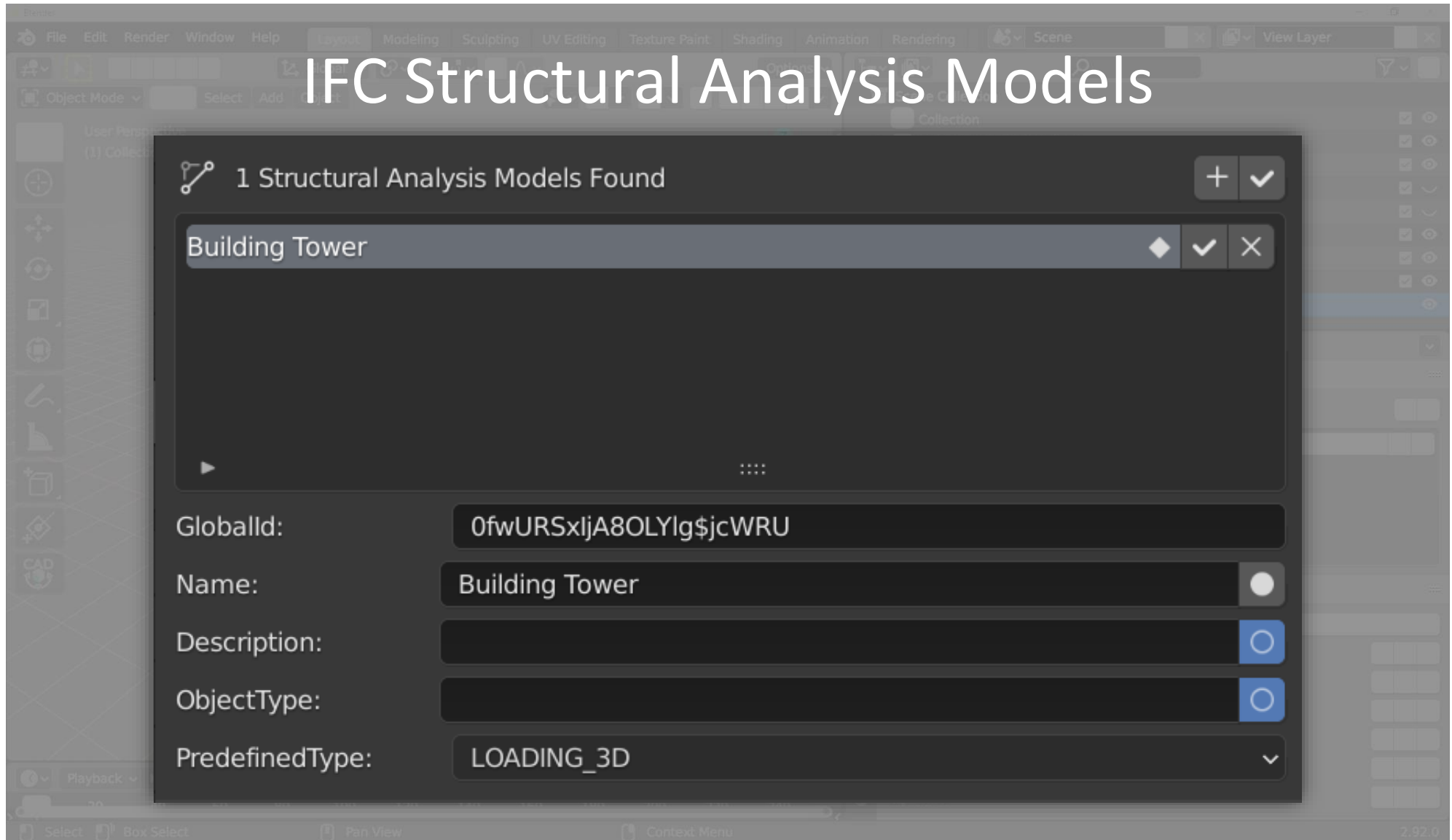


Blender and the BlenderBIM Add-On



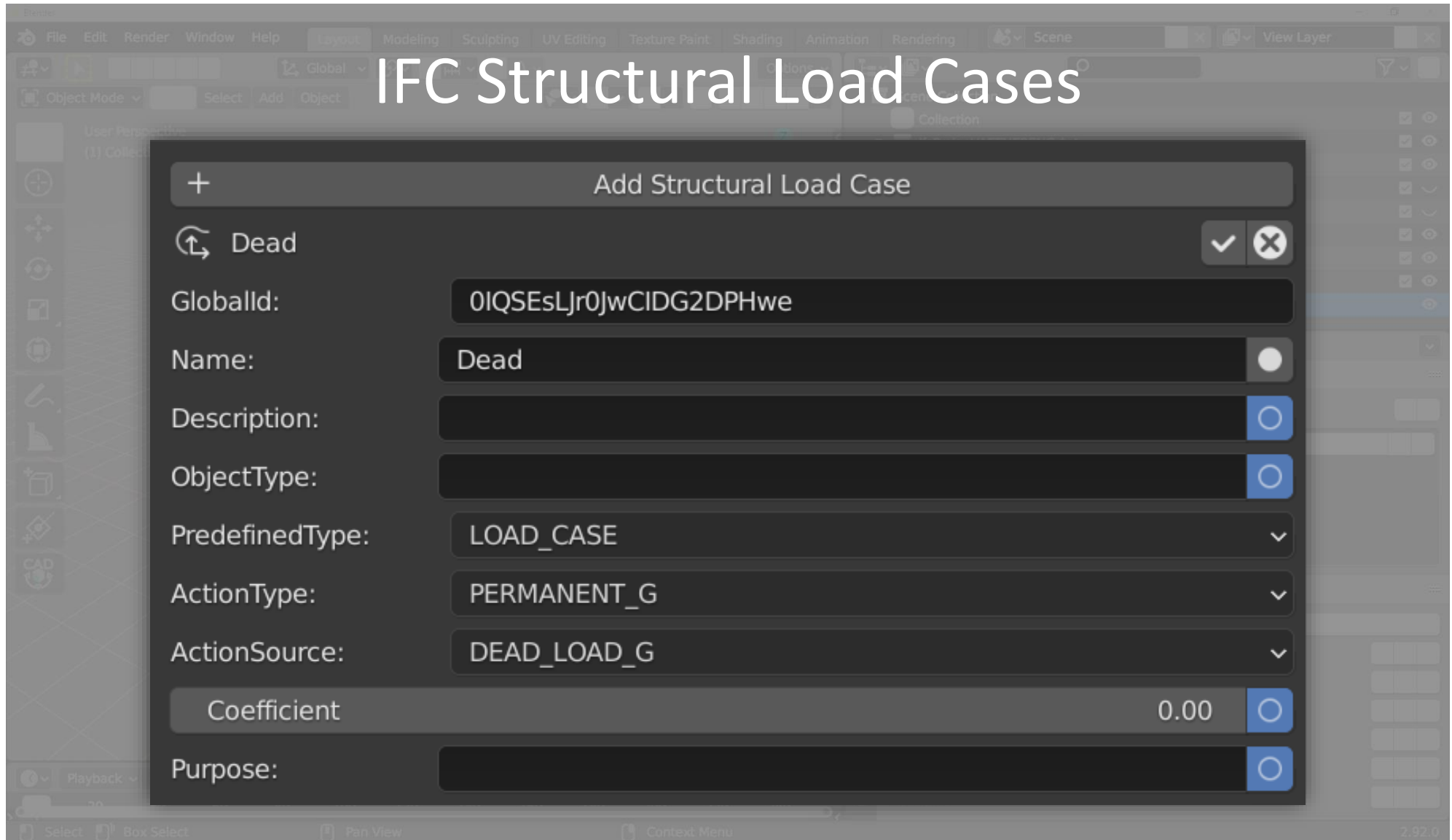
Blender and the BlenderBIM Add-On

IFC Structural Analysis Models



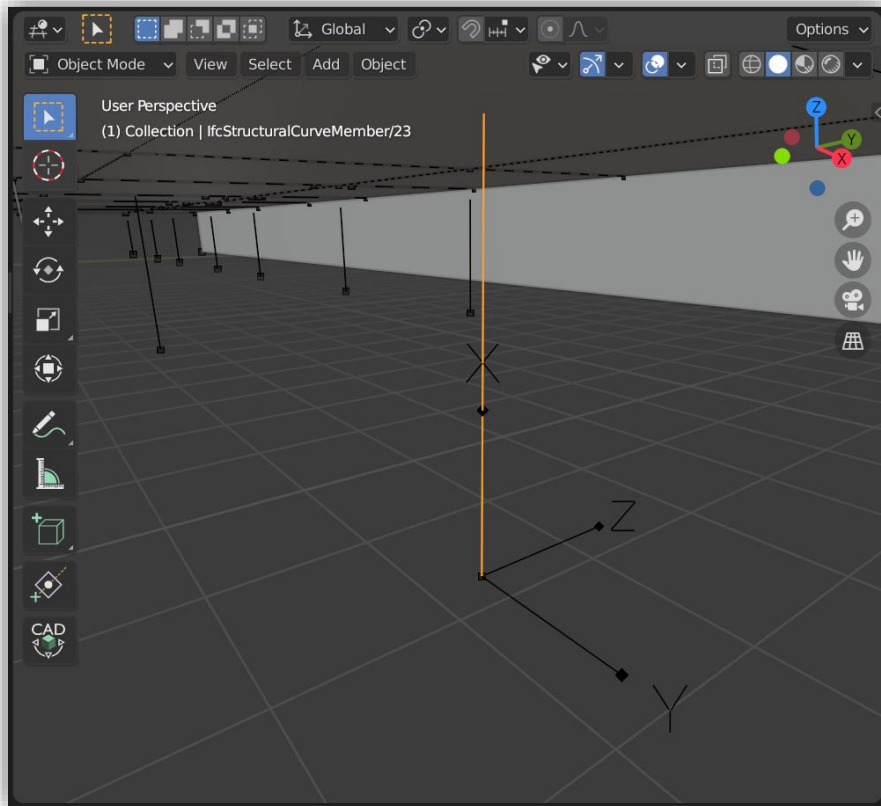
Blender and the BlenderBIM Add-On

IFC Structural Load Cases



Blender and the BlenderBIM Add-On

IFC Structural Members



Material:	<input type="text" value="C40"/>	<input type="button" value="✓"/>	<input type="button" value="✕"/>
Name:	<input type="text"/>	<input type="button" value="✓"/>	<input type="button" value="✕"/>
Description:	<input type="text"/>	<input type="button" value="✓"/>	<input type="button" value="✕"/>
Priority	<input type="text" value="0"/>	<input type="button" value="✓"/>	<input type="button" value="✕"/>
Category:	<input type="text"/>	<input type="button" value="✓"/>	<input type="button" value="✕"/>
	<input type="text" value="IfcArbitraryClosedProfileDef"/>	<input type="button" value="✓"/>	<input type="button" value="✕"/>
ProfileType:	<input type="text" value="AREA"/>	<input type="button" value="✓"/>	<input type="button" value="✕"/>
ProfileName:	<input type="text" value="C800X300"/>	<input type="button" value="✓"/>	<input type="button" value="✕"/>
XDim	<input type="text" value="300.00"/>	<input type="button" value="✓"/>	<input type="button" value="✕"/>
YDim	<input type="text" value="800.00"/>	<input type="button" value="✓"/>	<input type="button" value="✕"/>

Axis Angle

-90.00



Blender and the BlenderBIM Add-On

IFC Profiles / Sections

IfcParameterizedProfileDef

IfcRectangleProfileDef

ProfileType: AREA

ProfileName:

XDim0.00

YDim0.00

IfcParameterizedProfileDef

IfcCircleProfileDef

ProfileType: AREA

ProfileName:

Radius0.00

Blender and the BlenderBIM Add-On

IFC Profiles / Sections

IfcParameterizedProfileDef

IfcIShapeProfileDef

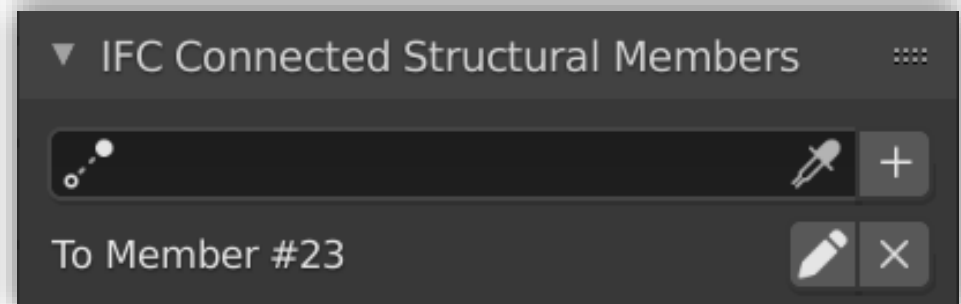
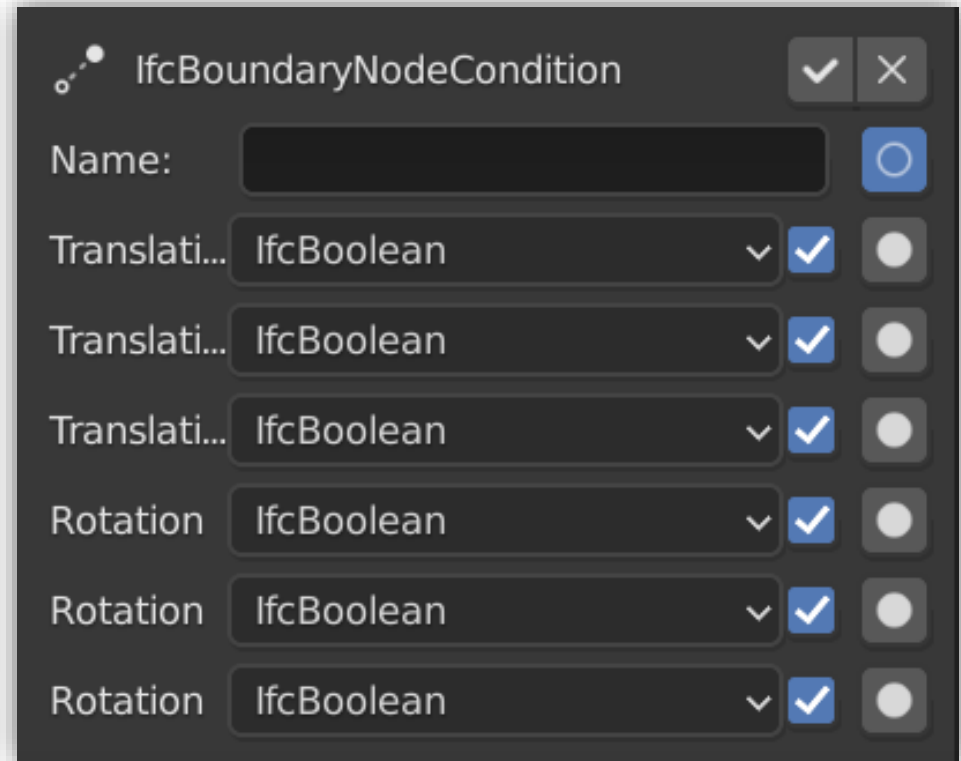
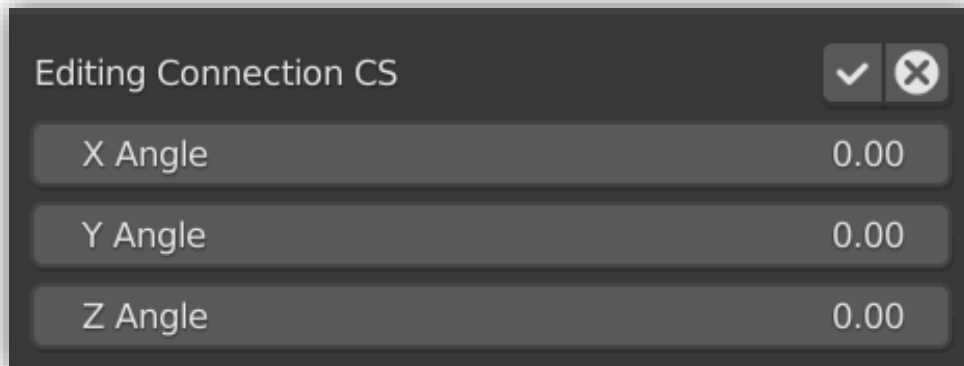
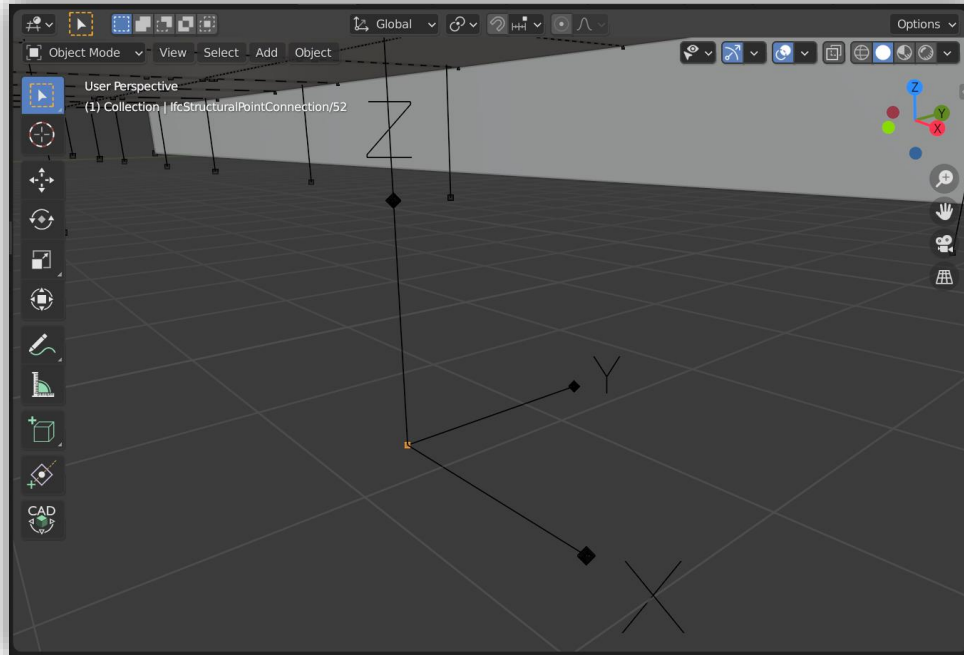
ProfileType: AREA

ProfileName:

OverallWidth	0.00	
OverallDepth	0.00	
WebThickness	0.00	
FlangeThickness	0.00	
FilletRadius	0.00	<input type="checkbox"/>
FlangeEdgeRadius	0.00	<input type="checkbox"/>
FlangeSlope	0.00	<input type="checkbox"/>

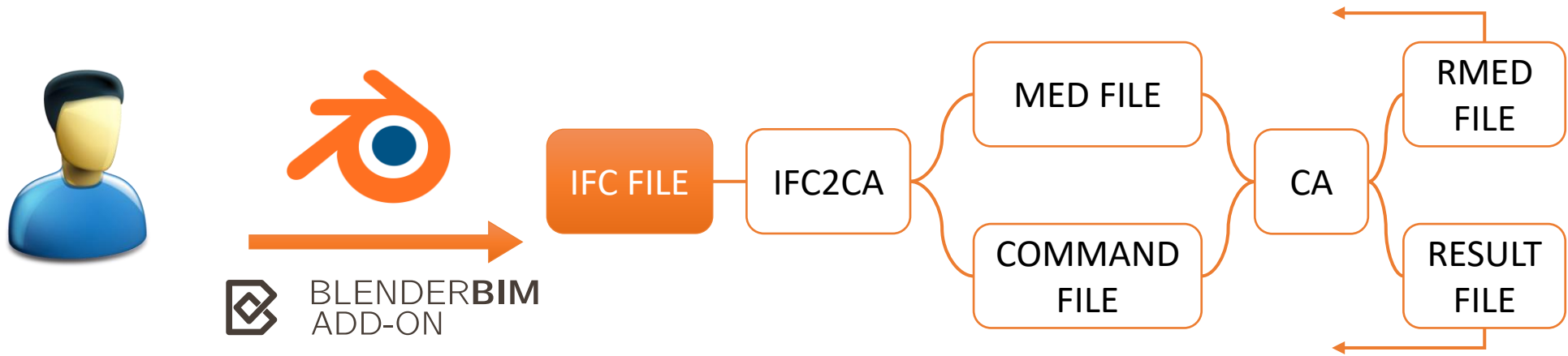
Blender and the BlenderBIM Add-On

IFC Structural Connections



Structural Workflow with Code_Aster

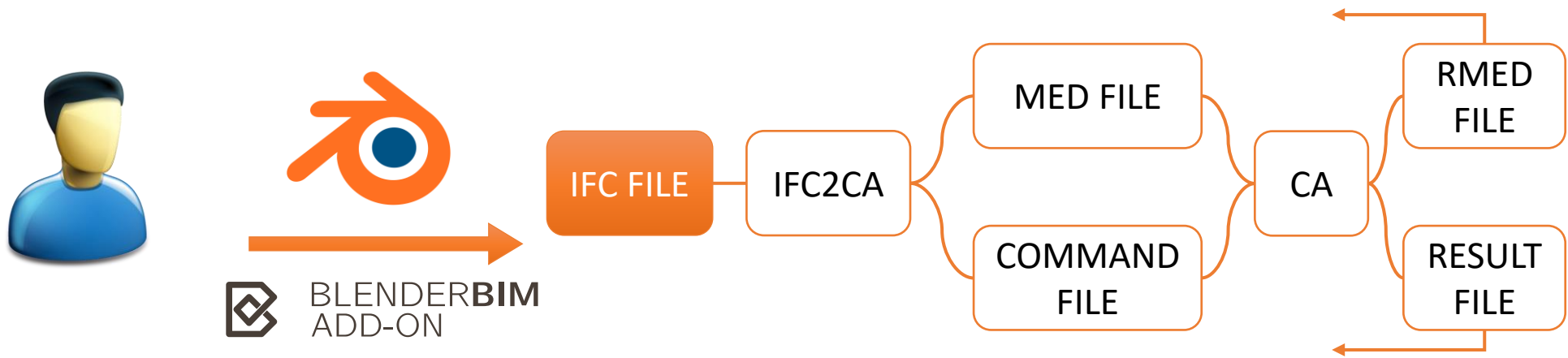
- openBIM Structural Pipeline



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

Structural Workflow with Code_Aster

- openBIM Structural Pipeline



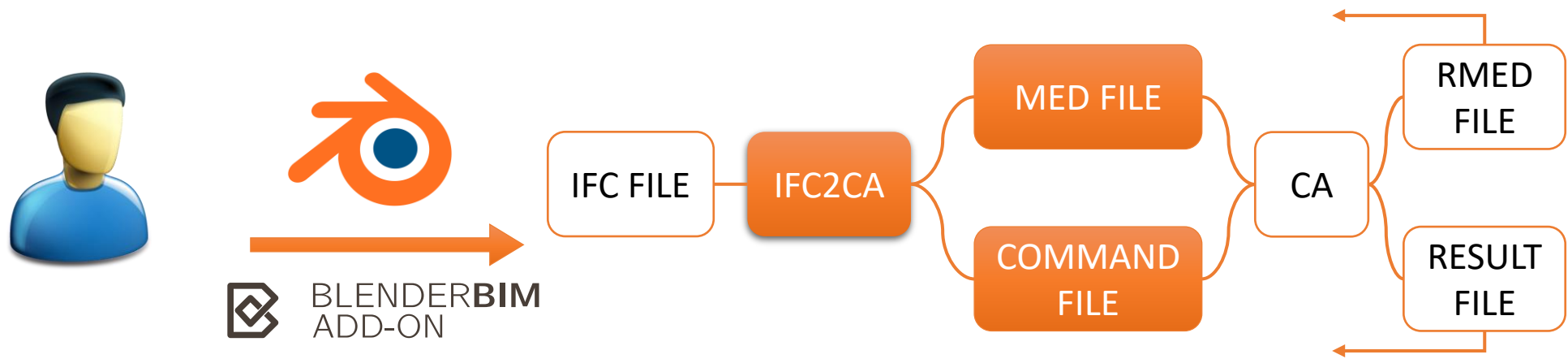
- ✓ I/O with a Blender Agnostic Python Library
`ifcopenshell.api`



- ✓ Native handling of IFC files
- ✓ Specific editing of parts of an IFC file within a Usecase

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

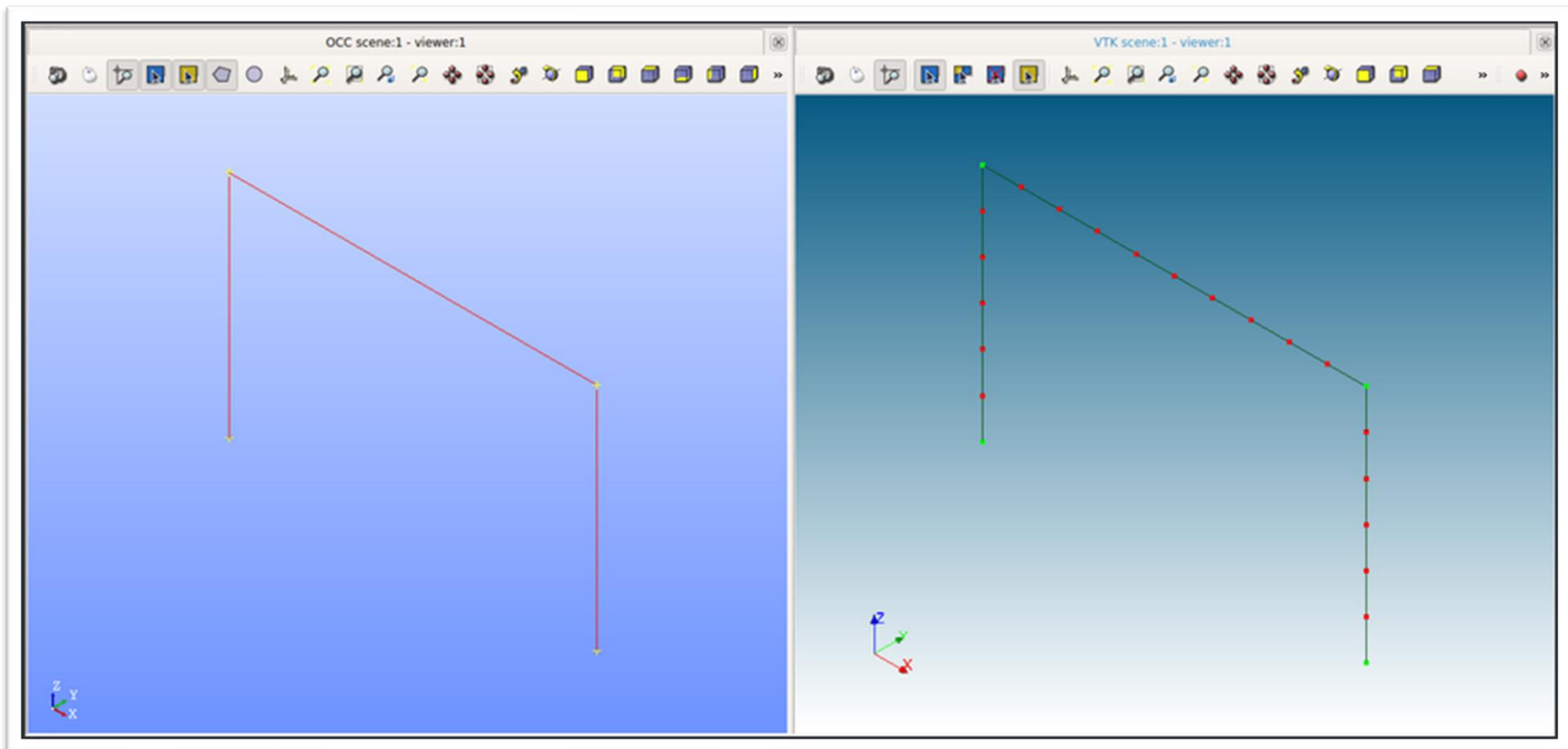
MED FILE

COMMAND
FILE



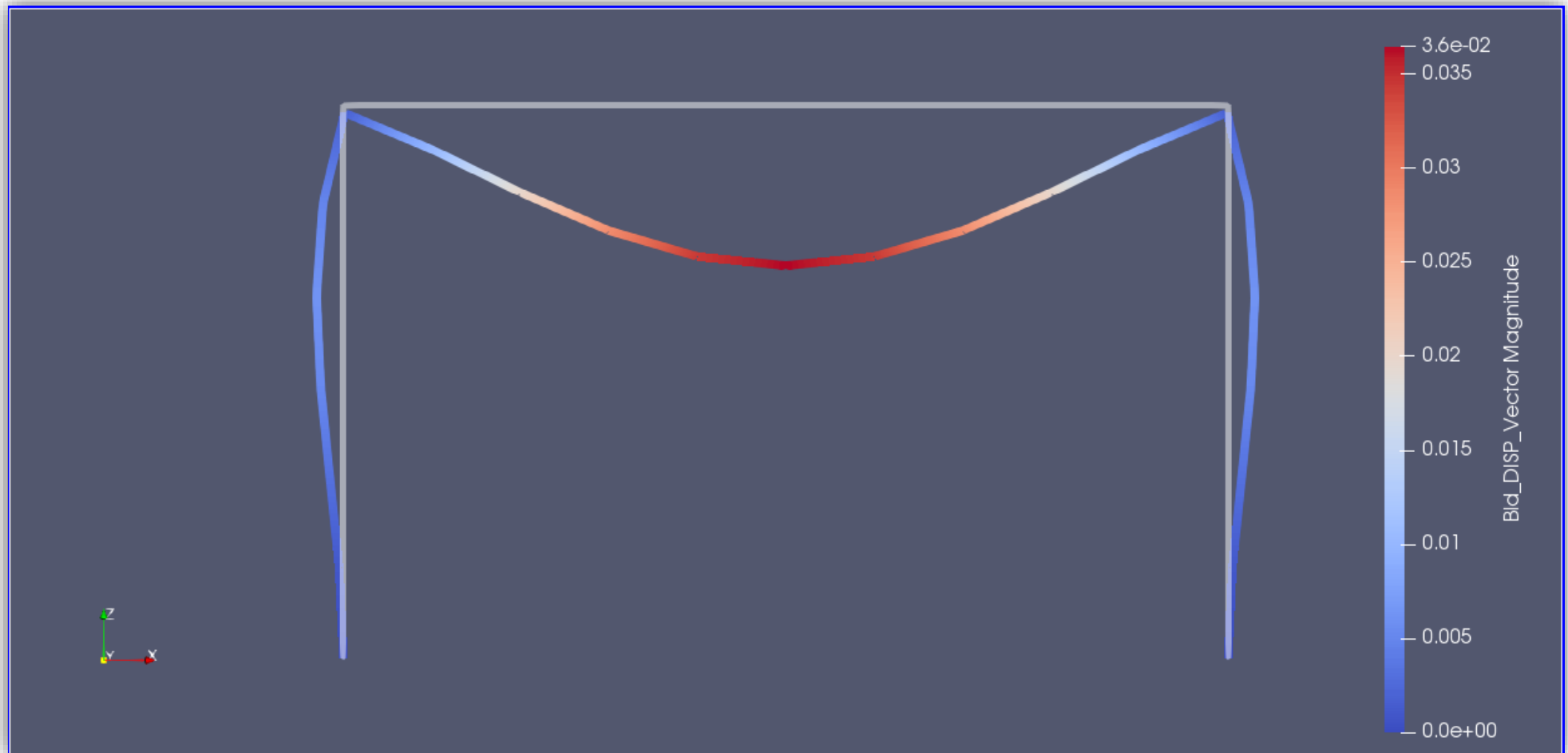
IFC-To-Code_Aster

Portal_01 Example

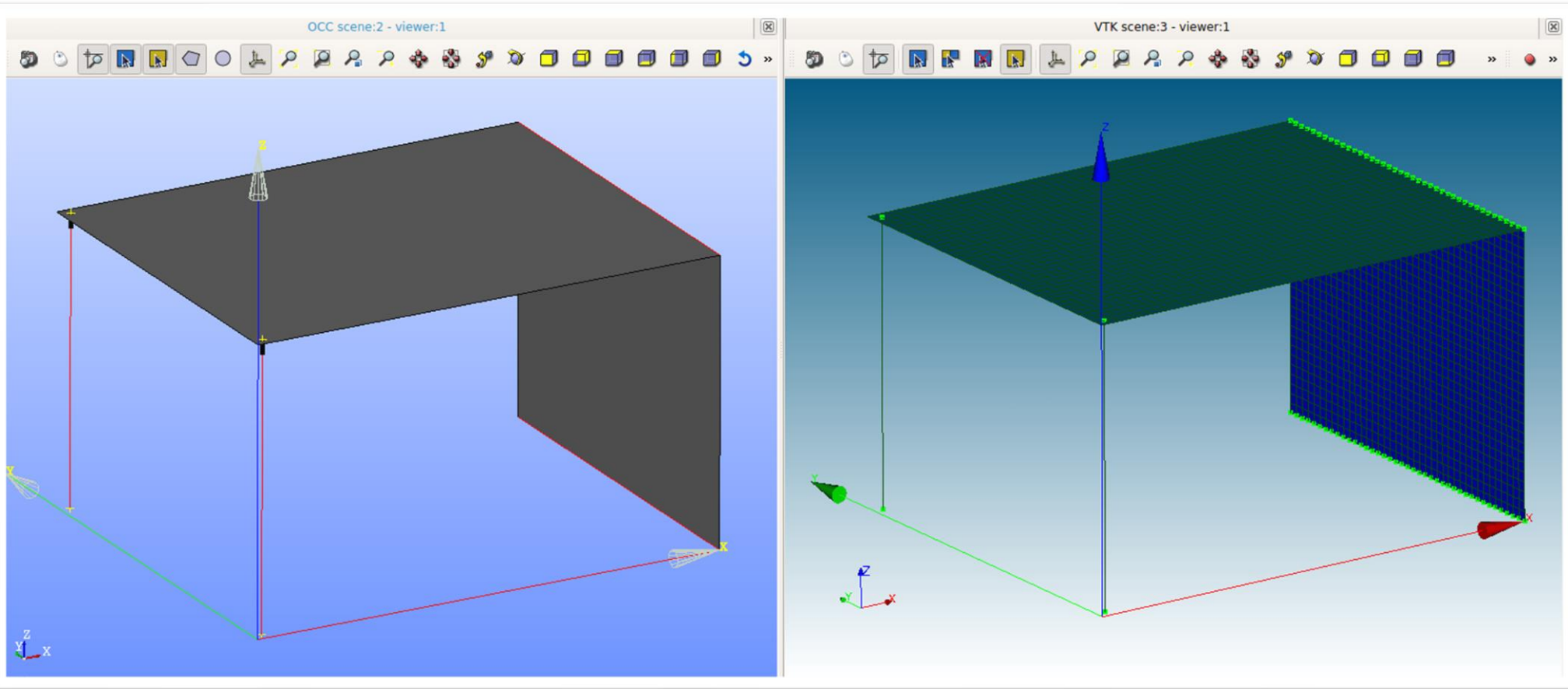


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Portal_01 Example

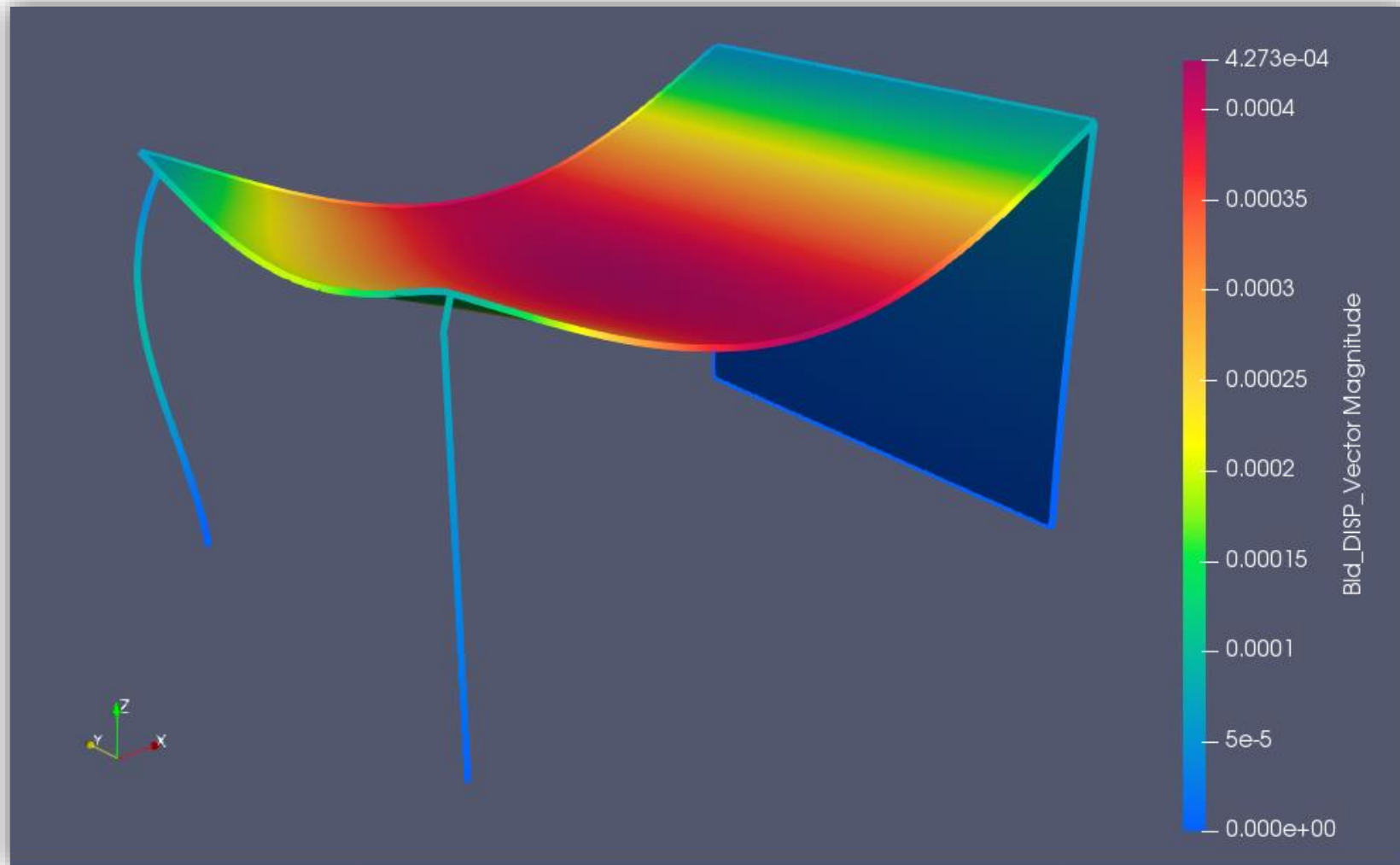


IFC-To-Code_Aster Structure_01 Example

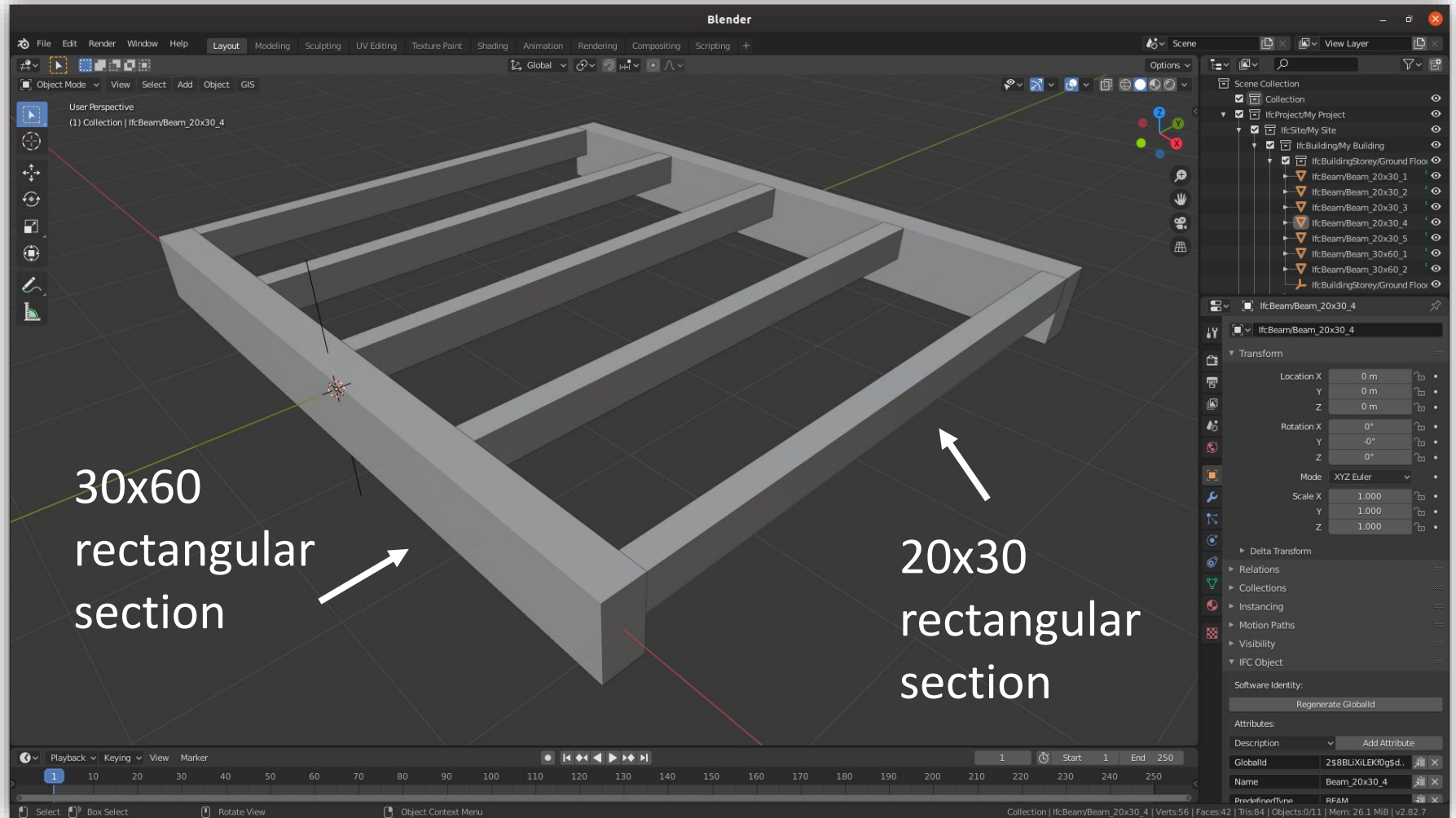


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Structure_01 Example

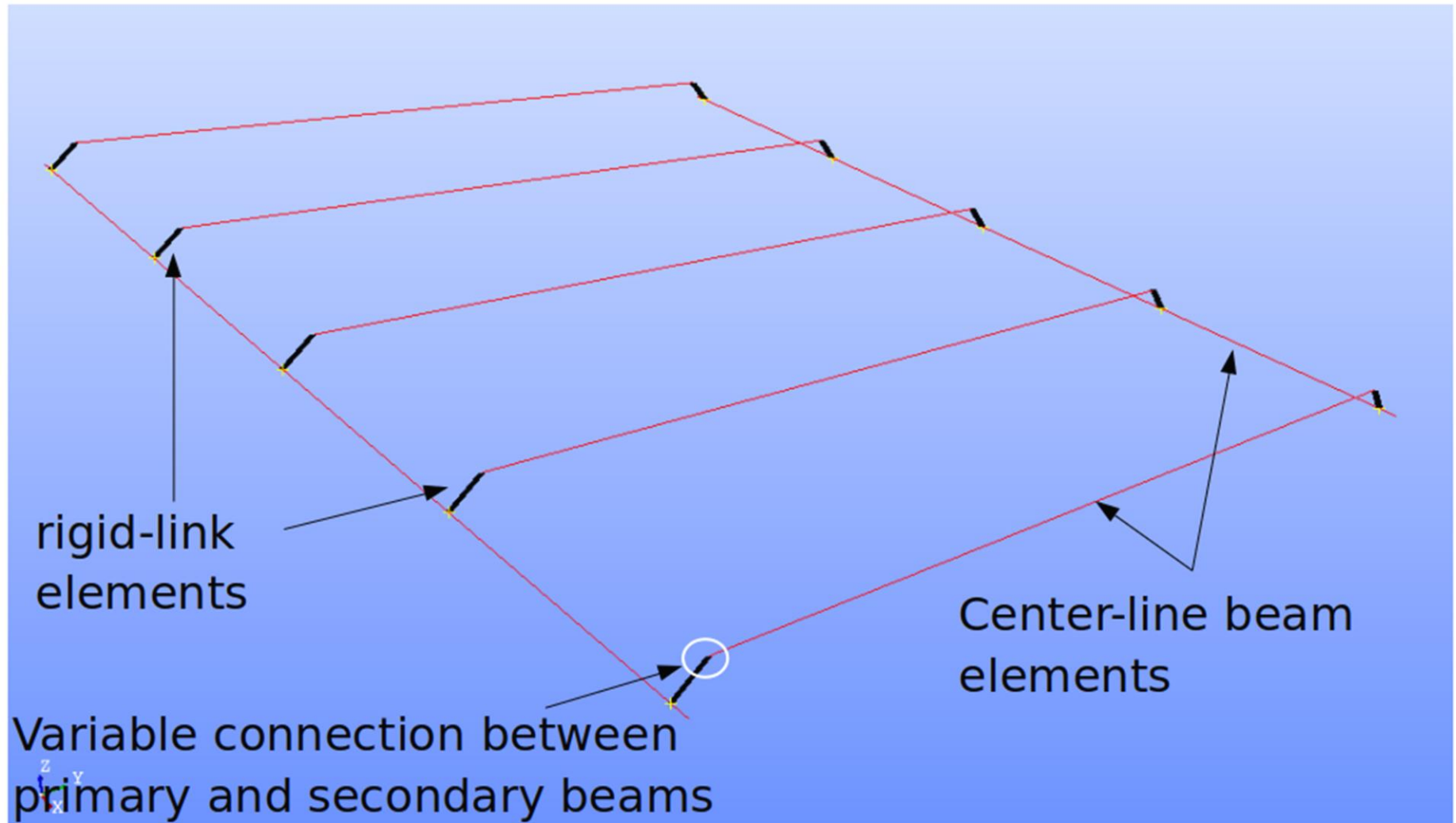


IFC-To-Code_Aster Grid_of_beams Example



IFC-To-Code_Aster

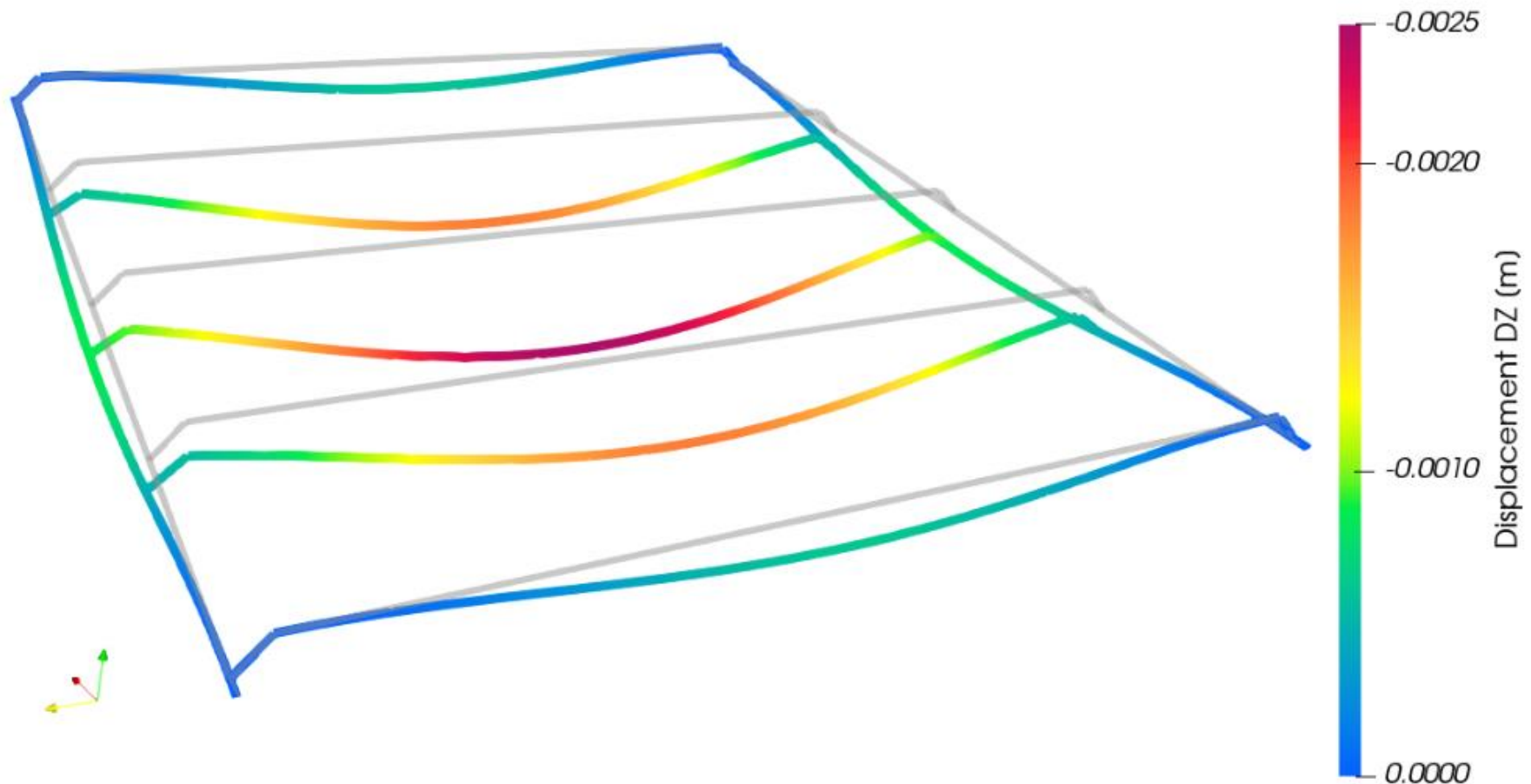
Grid_of_beams Example



IFC-To-Code_Aster

Grid_of_beams Example

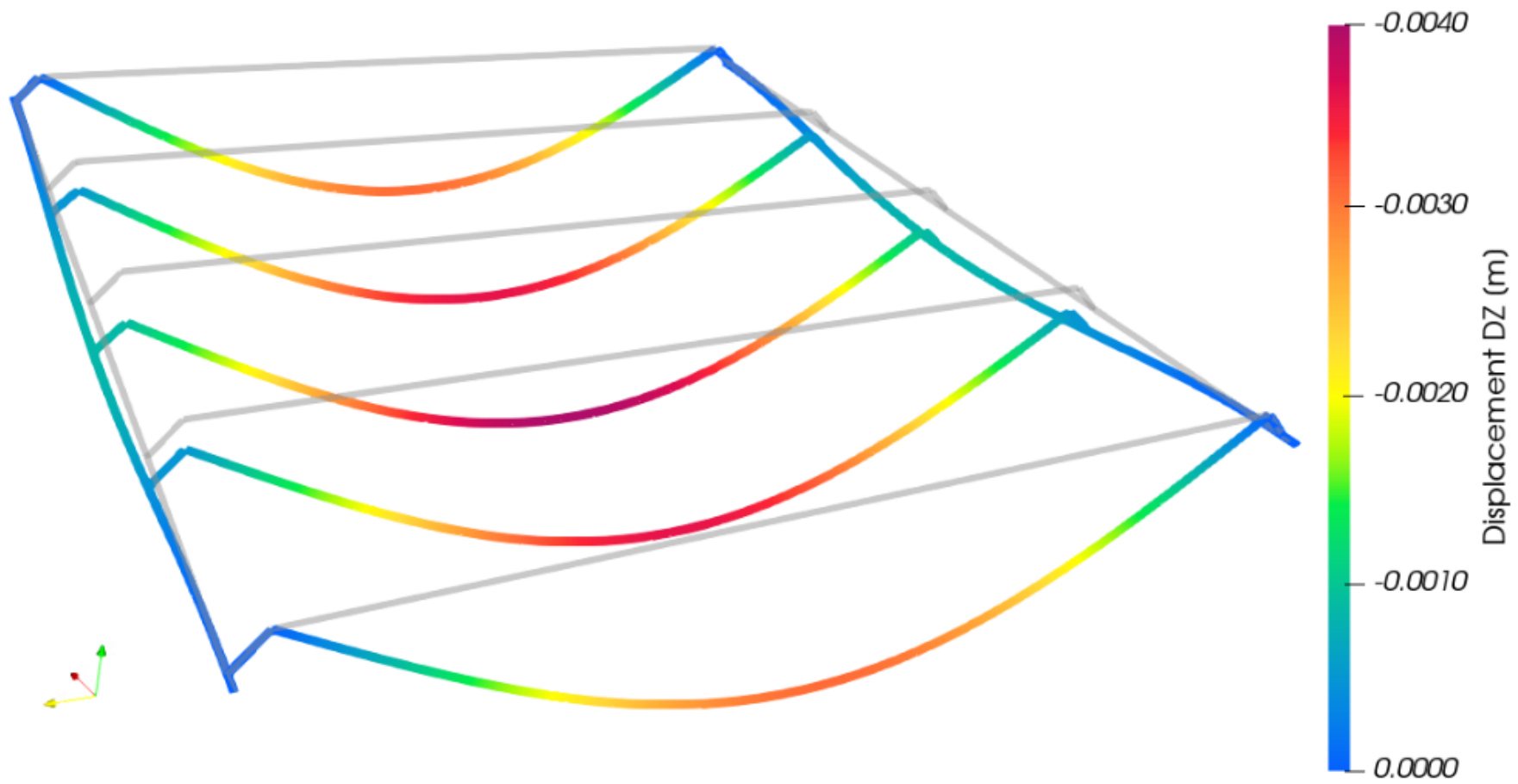
Fixed connections | $dz_{max} = 2.5 \text{ mm}$



IFC-To-Code_Aster

Grid_of_beams Example

Pinned connections | **dz_max = 4.0 mm**

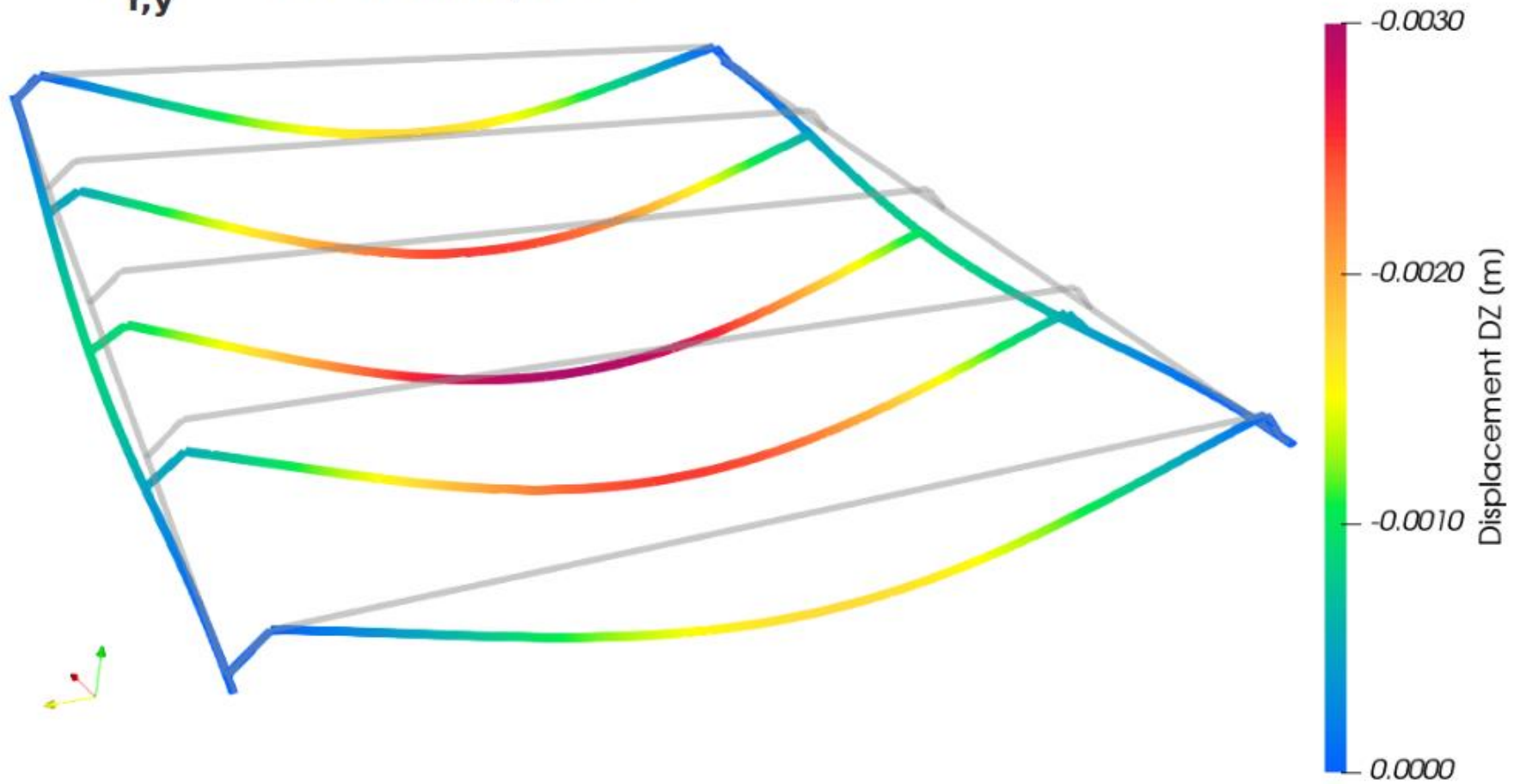


IFC-To-Code_Aster

Grid_of_beams Example

Flexible connections | **dz_max = 3.0 mm**

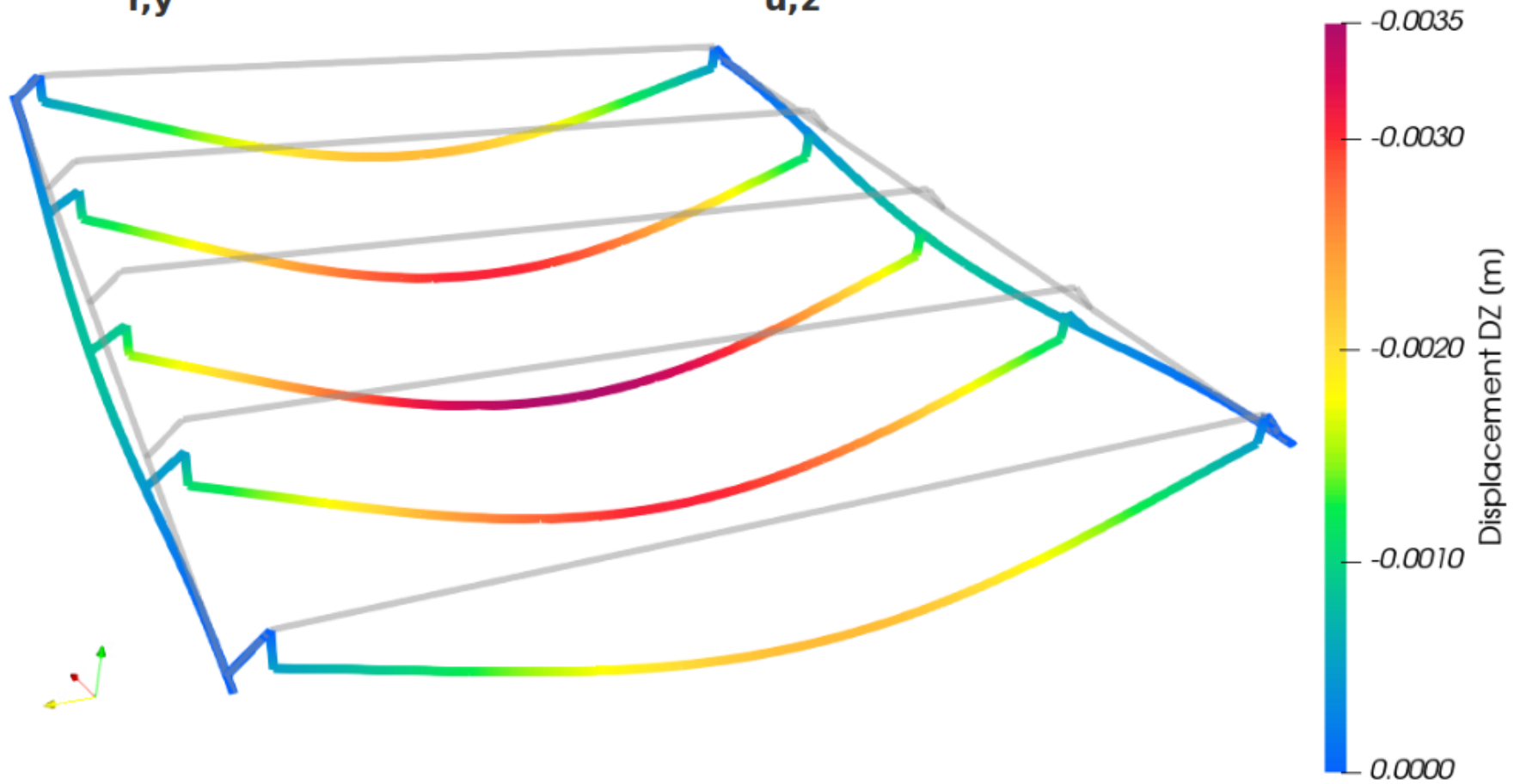
$K_{r,y} = 50$ kNm/rad



IFC-To-Code_Aster

Grid_of_beams Example

Flexible connections | $dz_{max} = 3.5 \text{ mm}$
 $K_{r,y} = 50 \text{ kNm/rad}$ & $K_{u,z} = 200 \text{ kN/m}$




IFC-To-Code_Aster

Grid_of_beams Example


Flexible connections | $dz_{max} = 3.5 \text{ mm}$

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

-0.0035

 IfcBoundaryNodeCondition ✓ ✕


Name:



TranslationalStiff...

IfcBoolean


✓



TranslationalStiff...

IfcBoolean


✓



Translati...

IfcLinearStiffnessMeasure


200.00



RotationalStiffne...

IfcBoolean


✓



Rotation...

IfcRotationalStiffnessMeasure


50.00



RotationalStiffne...

IfcBoolean

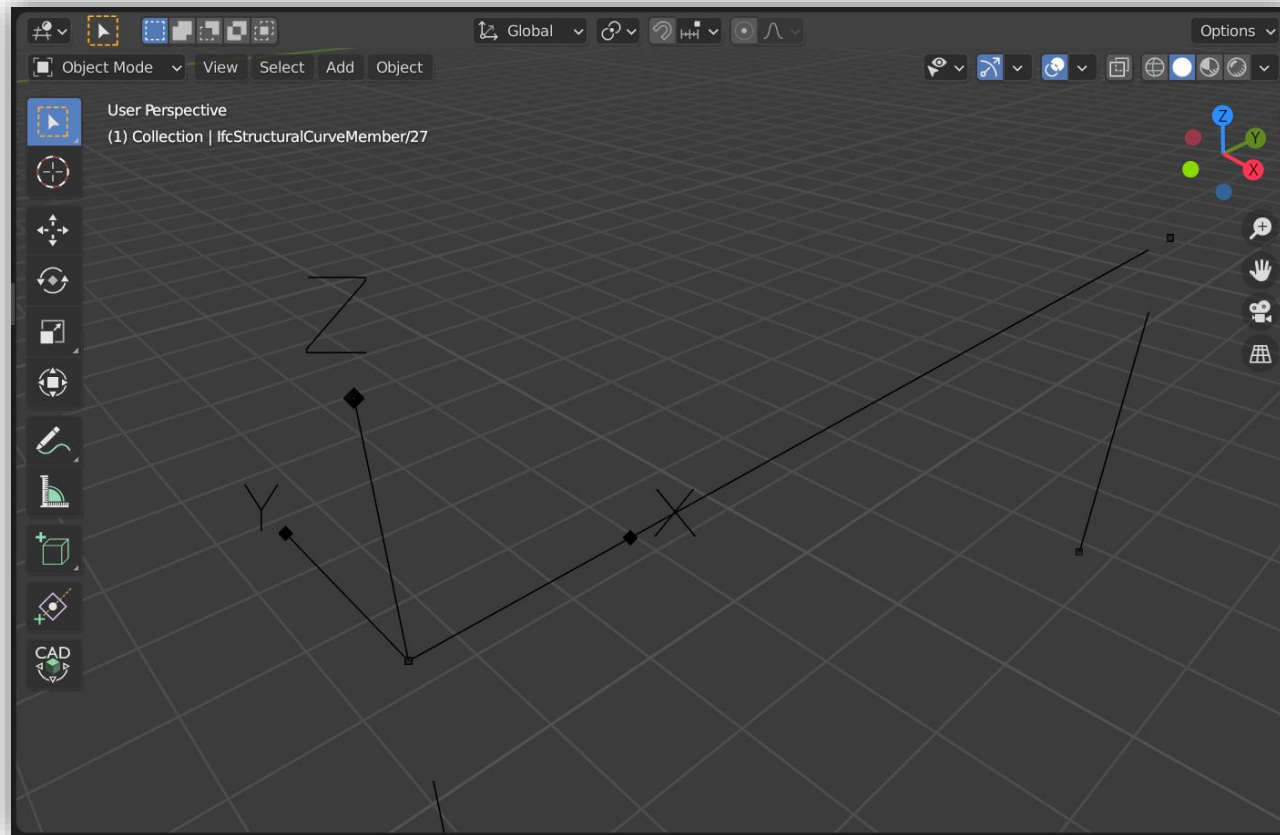
✓



IFC-To-Code_Aster

Grid_of_beams Example

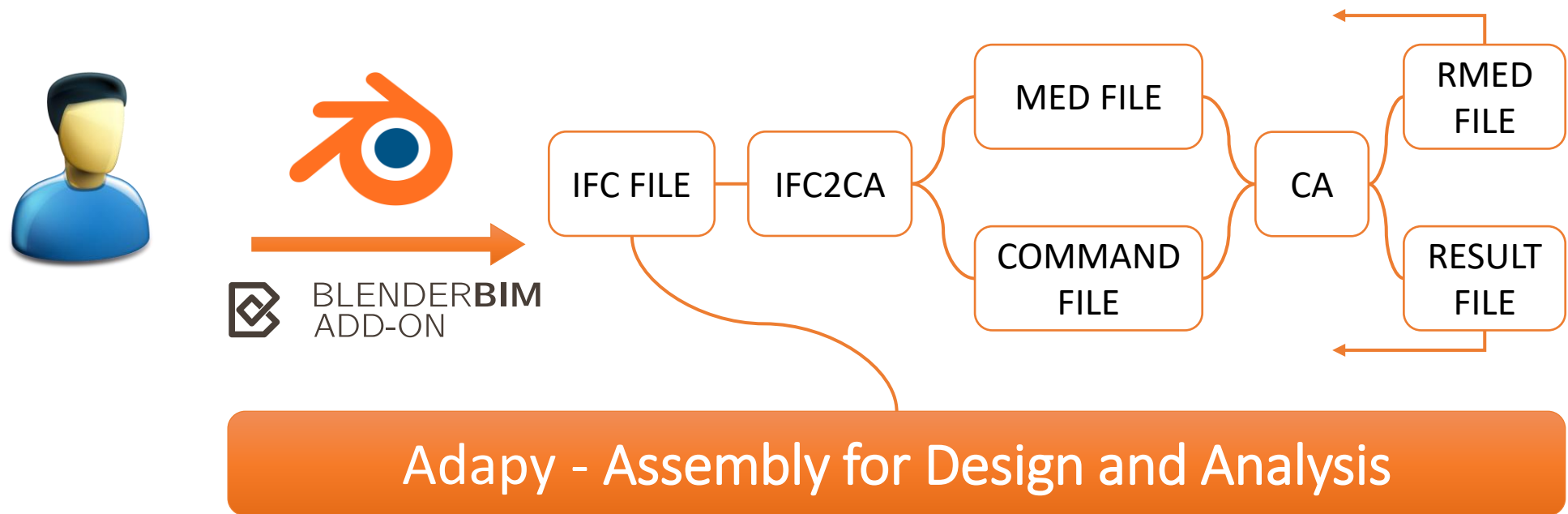
Flexible connections | $dz_{\max} = 3.5 \text{ mm}$
 $K_{r,y} = 50 \text{ kNm/rad}$ & $K_{u,z} = 200 \text{ kN/m}$



-0.0035

Structural Workflow with Code_Aster

- openBIM Structural Pipeline

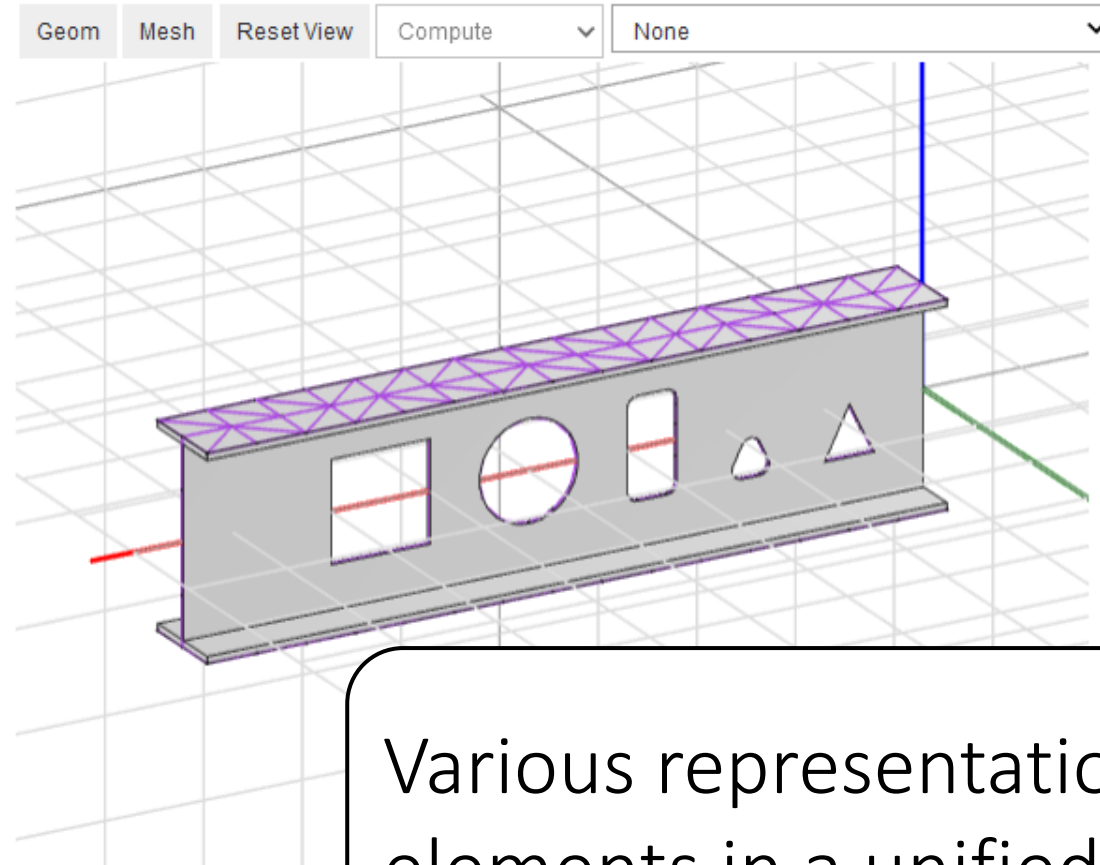


- Released in 2021 by **Kristoffer Andersen**
- A python package that focuses on interoperability between IFC and various Finite Element formats

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"



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 files

Created a Code Aster input deck

starting Code Aster simulation

Finished Code Aster simulation

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

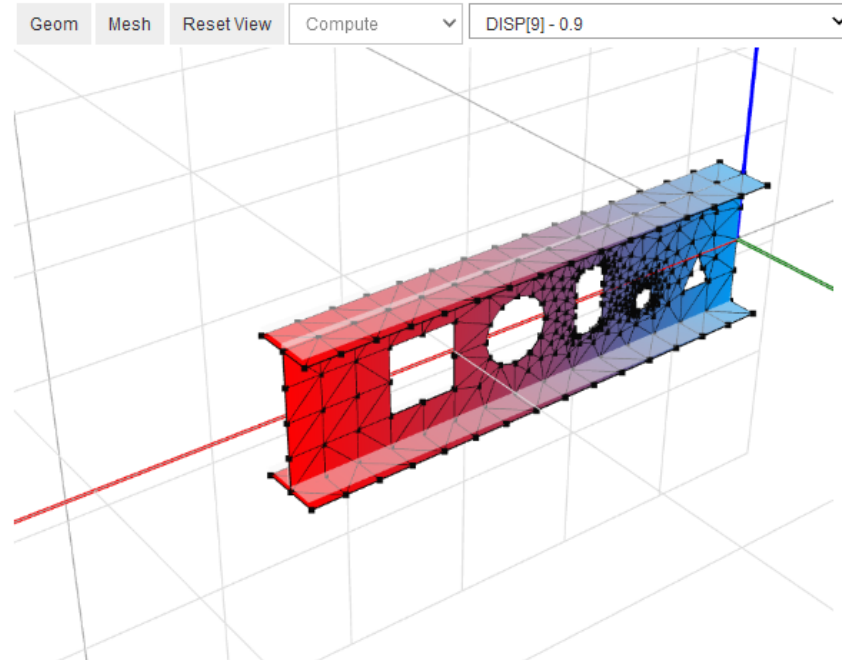
In [2]: a = beam_ex1()
        res = a.to_fem("MyCantilever_code_aster", "code_aster", overwrite=True, execute=True)

        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



Creating a built environment with
free software, increased
transparency, and a more ethical
approach

OSArch is for the architects, engineers, designers, builders, planners, operators, and you.
Let's change the industry together.

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

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1. Concept design
2. GIS
3. Visualisation
4. Geometry scan-process
5. CAD/BIM
6. Mesh Generator
7. Structural Analysis
8. Environmental Analysis
9. Project Management
10. Facility Management
11. Software Development
12. Proprietary software

WIKI SOFTWARE DIRECTORY

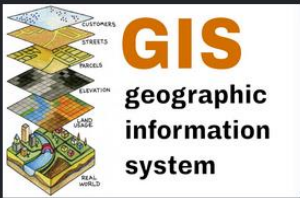
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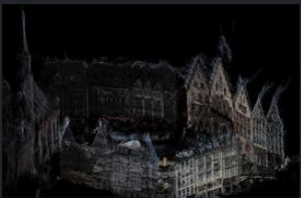
1 - Concept design




2 - GIS



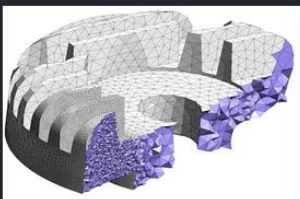
3 - Visualisation



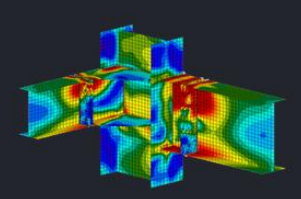
4 - Geometry scan-process



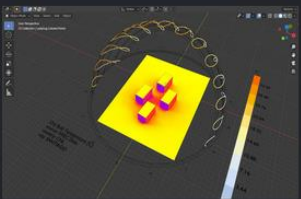
5 - CAD/BIM




6 - Mesh Generator




7 - Structural Analysis




8 - Environmental Analysis




9 - Project Management



10 - Facility Management



11 - Software Development



12 - Proprietary software

Thank you!

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