STKO

A revolutionary toolkit for opensees

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ASDEA
SOFTWARE
TECHNOLOGY

Outline

- Introduction and motivations
- STKO: pre and post processor
- Adopted database: HDF5
- Proposed file format: MPCO
- New recorder class: MPCORecorder
- Numerical applications
- Conclusions and future works

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1 Introduction and motivations

Introduction and motivations

Introduction and motivations

- Simulation of real-life structures
  - Real-life complex models
  - High-volume output data
  - Heterogeneous results
- Efficient layout of complex data in the database
- Lack of visualization tools for results on fibers and in general 1D element
- Interaction with the database via scripting
  - Extrapolation
  - Manipulation
  - New custom results

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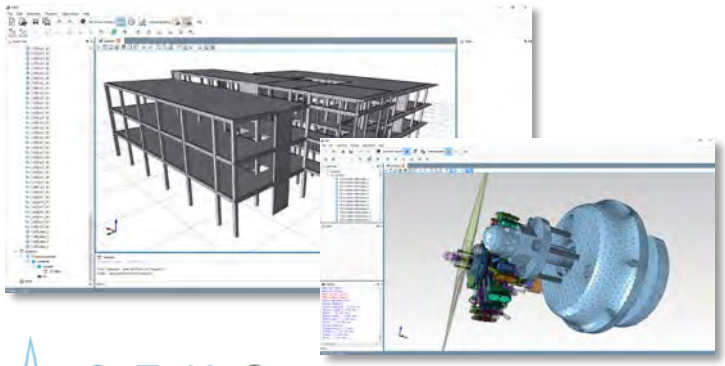
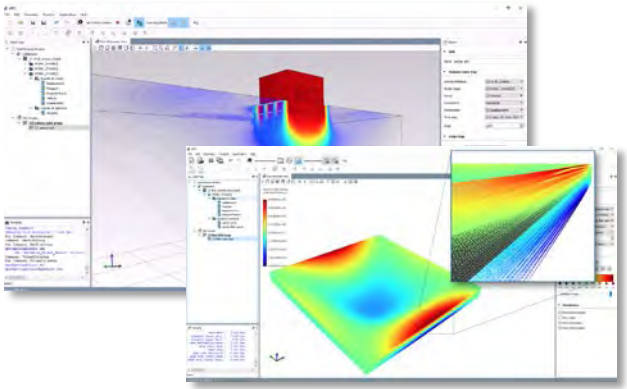
STKO: pre and post processor

A brief description of the STKO pre and post processor

STKO: pre and post processor

- **Pre-processor**
  - CAD importer, modeler and mesher
  - Based on OpenCascade library (https://www.opencascade.com/)
  - Scripting interface for linking with the external solver
- **Post-processor**
  - HDF5-based output database (https://www.hdfgroup.org/)
  - Standard plot tools
  - Advanced plot tools for beam elements
  - Scripting interface for interaction with the Database





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Adopted database: HDF5

What is HDF5 and why did we choose it ?

For more info:

The HDF Group, "Hierarchical Data Format, version 5," 1997-2017. [Online]. Available: http://www.hdfgroup.org/HDF5/

Adopted database: HDF5

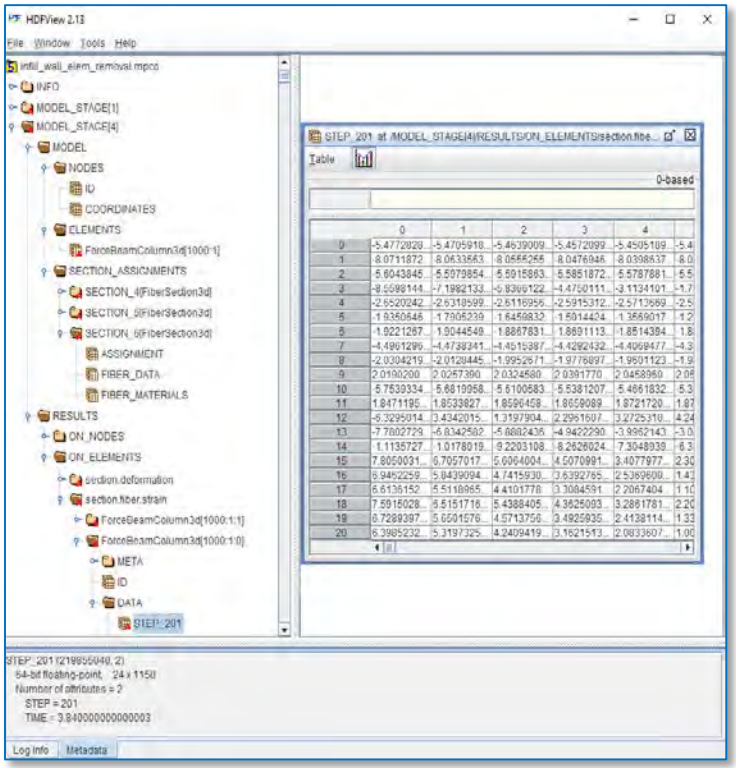
Why HDF5 ?

- Opensource (BSD license) library
- Completely portable file format
- No limit on the number or size of data objects in the collection
- Runs on a range of computational platforms, from laptops to massively parallel systems
- Several languages: C, C++, Fortran90, Java, Python
- Parallel I/O

Adopted database: HDF5

What does a HDF5 file look like?

- Hierarchical structure
- Groups (directories)
- Datasets (data)
- Attributes (metadata)



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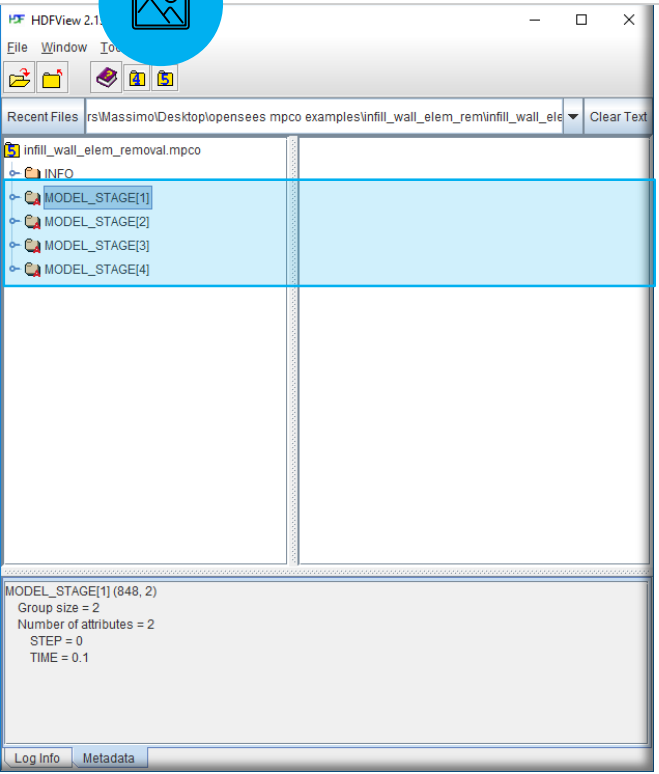
4 Proposed file format: MPCO

How to lay out complex data

Proposed file format: MPCO

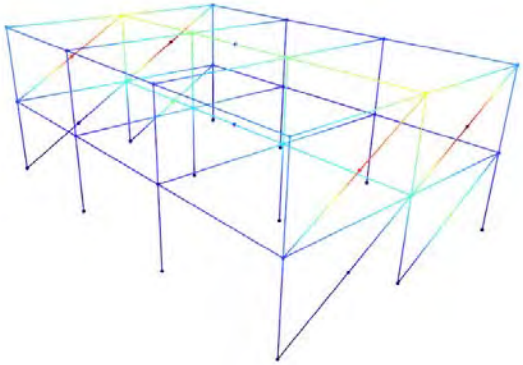
What do we need to store in our output file?

- Model (+ model stages)
  - Nodes
  - Elements
    - Geometries + standard and custom integration rules
  - Sections and materials + assignments
- Results
  - Results stored on nodes
  - Results stored on elements
    - On element nodes
    - On integration points
    - On sub-integration points (fibers)



Model Stages:

- Changes in the original model
- Added/removed elements/nodes



From OpenSees Structural Examples

Infill Wall Model and Element Removal

M. Selim Gunay and Khalid M. Mosalam, University of California, Berkeley

http://opensees.berkeley.edu/wiki/index.php/Infill_Wall_Model_and_Element_Removal

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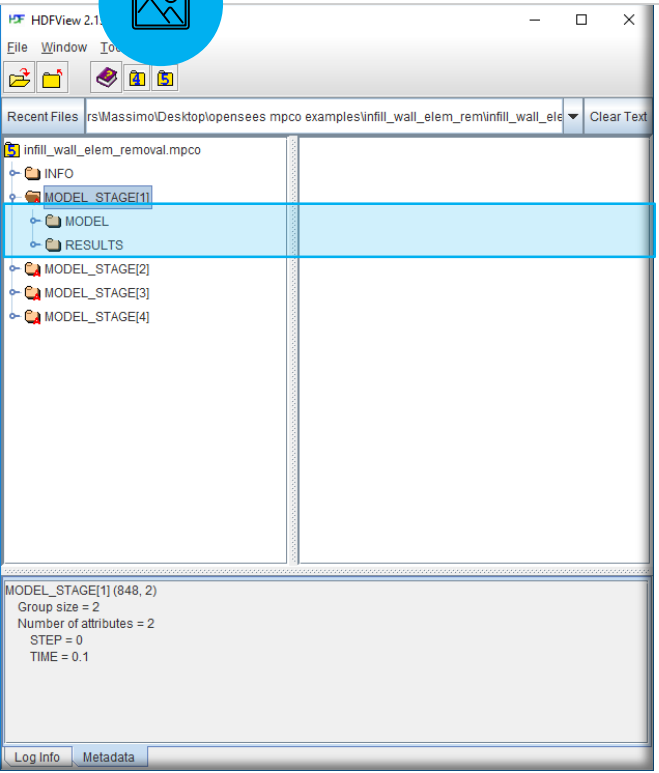

Each model stage group contains:

- Model informations
- Results

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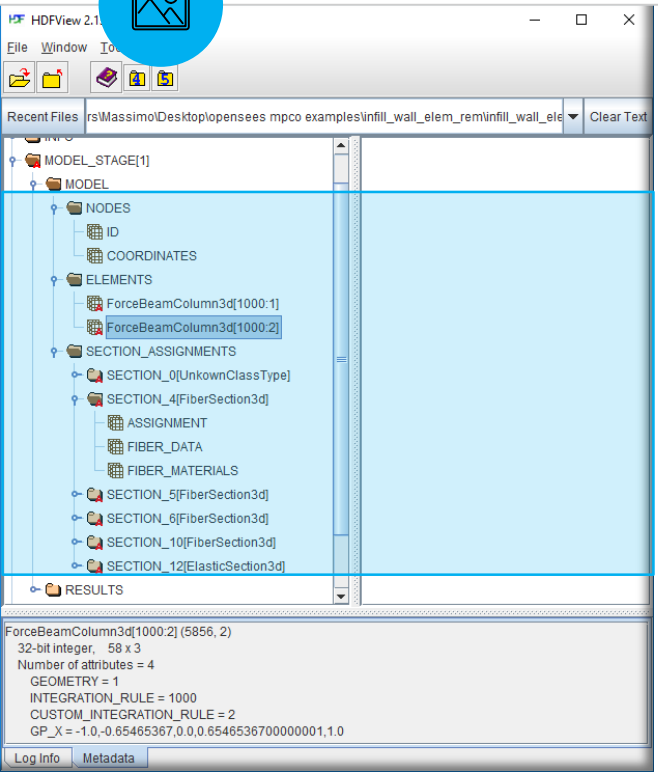

Each model group contains:

- Nodes
- Elements
  - Geometry
  - Standard and/or custom integration rules
- Section assignments
  - Element and gauss assignments
  - Fiber data
  - Fiber materials

Gauss points

Fibers

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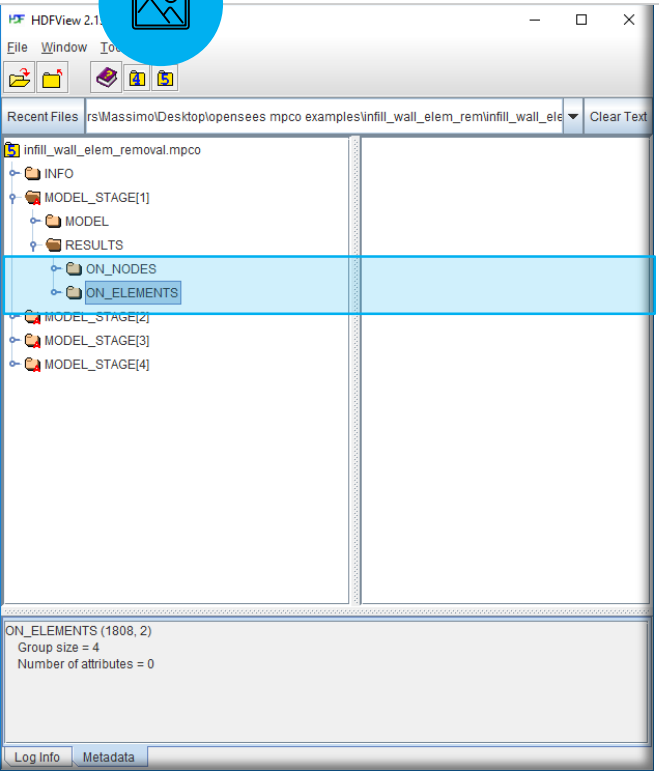

The result group contains:

- Results on nodes
- Results on elements

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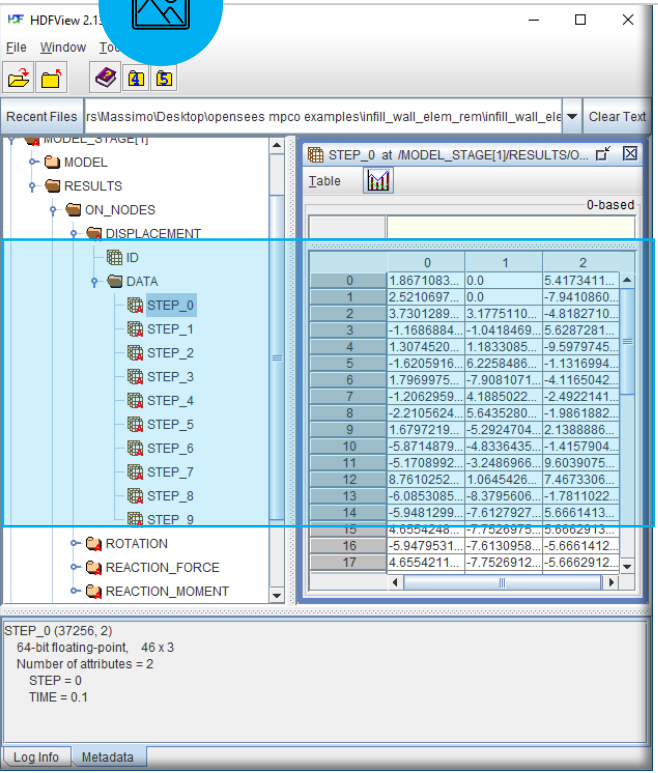

The node result contains:

- 1Dataset with selected node IDs
- 1Data group
- 1Dataset for each time step

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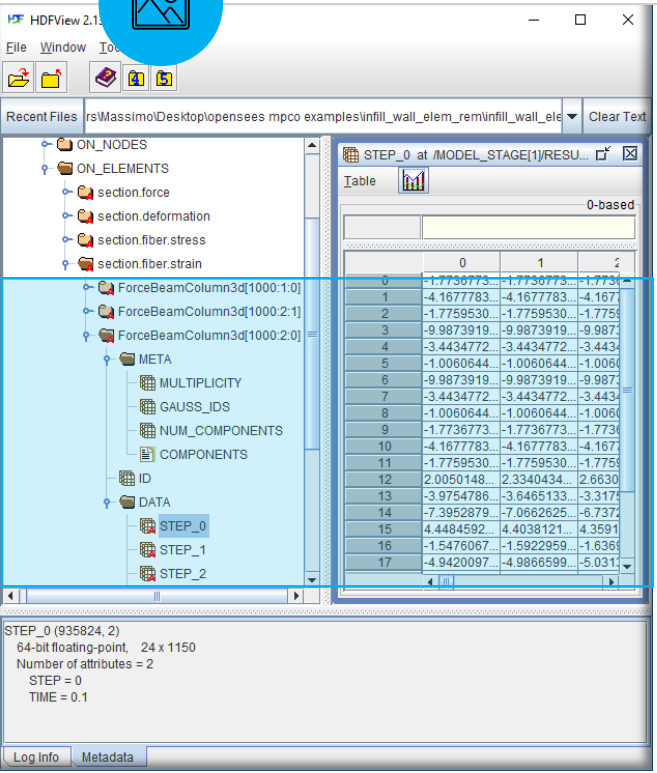

The element result contains:

- Groups based on:
  - Element type
  - Size of connectivity
  - Type of integration rule
  - Type of cross sections
- Each group contains:
  - Metadata group with:
    - Number of components + labels
    - Node or gauss ID
    - Multiplicity
  - 1 Dataset with selected element IDs
  - 1 Data group
  - 1 Dataset for each time step

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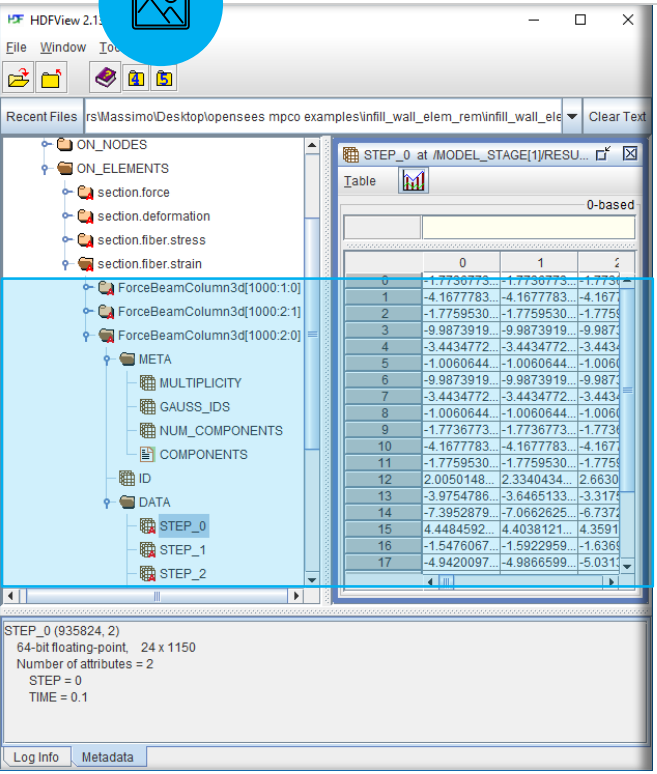
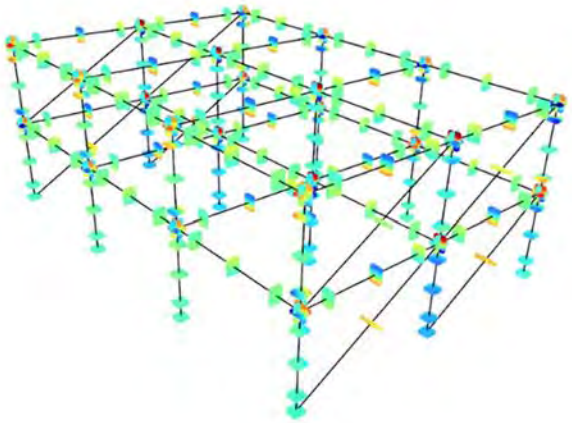


With the proposed layout we can obtain a large variety of plots:



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New recorder class: MPCORecorder

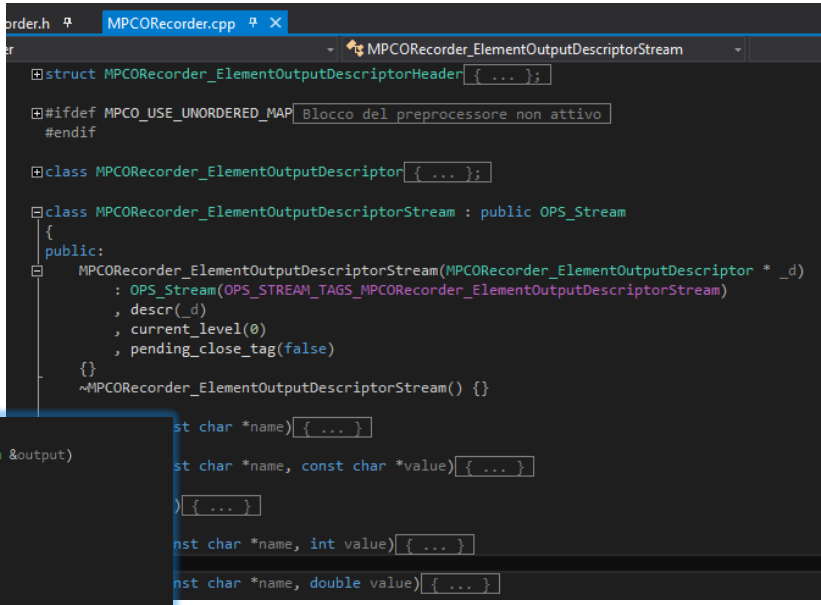
Implementation of the HDF5 based recorder in OpenSees

New recorder class: MPCORecorder

What element results are supported?

Everything, but the element MUST use the OPS_Stream!

MPCORecorder heavily relies on OPS_Stream




```
Response*
ForceBeamColumn3d::setResponse(const char **argv, int argc, OPS_Stream &output)
{
  Response *theResponse = 0;

  output.tag("ElementOutput");
  output.attr("eleType","ForceBeamColumn3d");
  output.attr("eleTag",this->getTag());
  output.attr("node1",connectedExternalNodes[0]);
  output.attr("node2",connectedExternalNodes[1]);
```

```
    for (int i=0; i<numSections; i++) {

      output.tag("GaussPointOutput");
      output.attr("number",i+1);
      output.attr("eta",xi[i]*L);

      Response *theSectionResponse = sections[i]->setResponse(&argv[1], argc-1, output);
```

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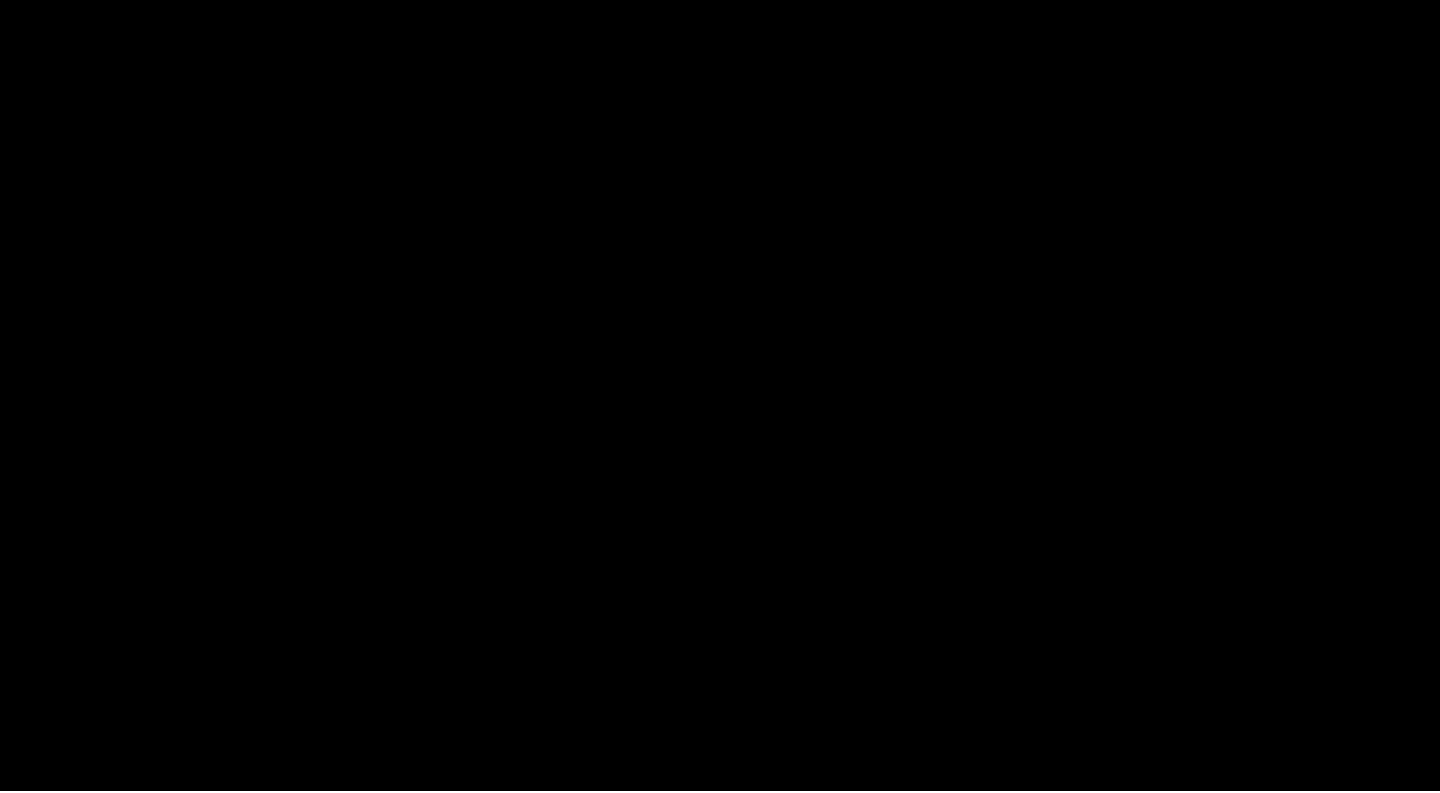
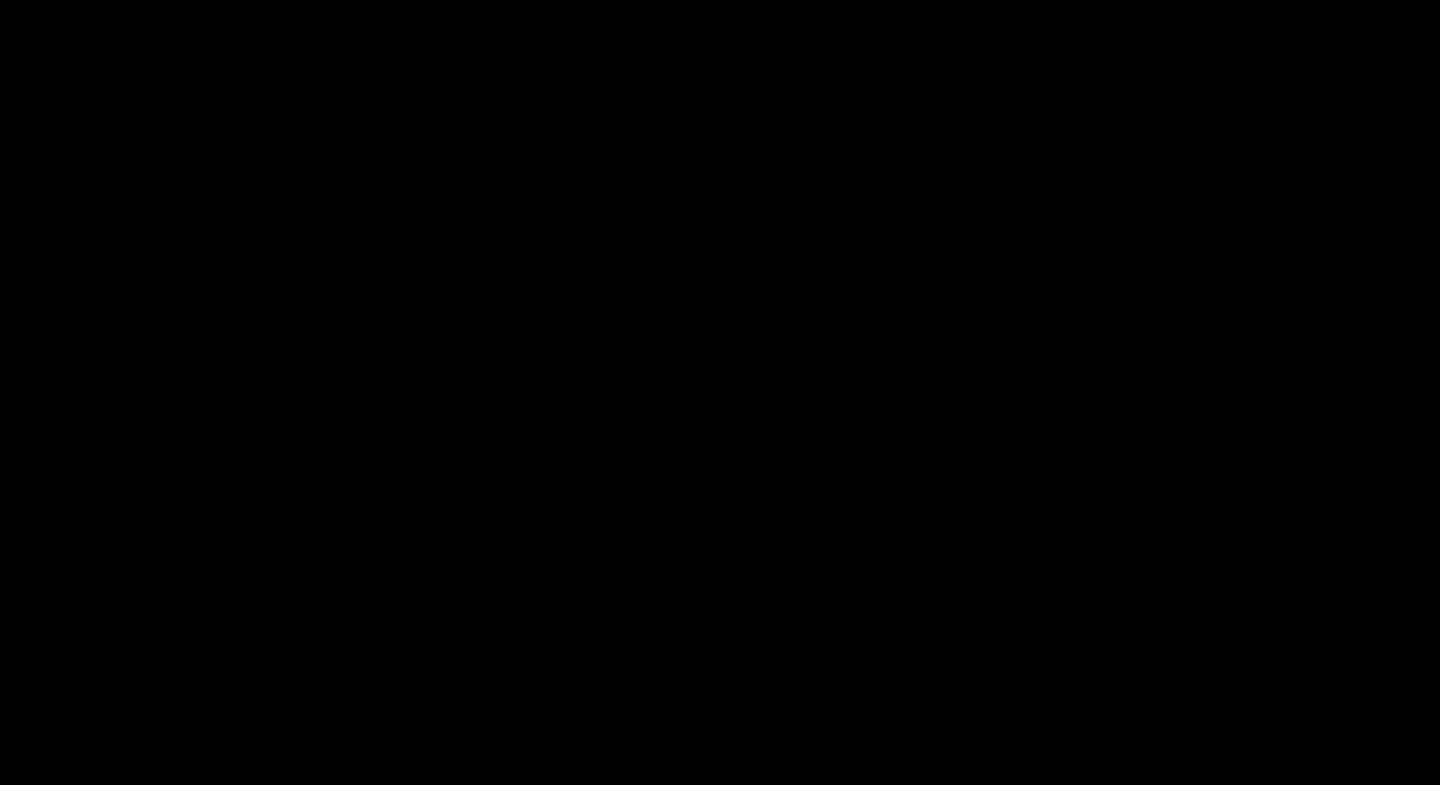
6 Numerical applications

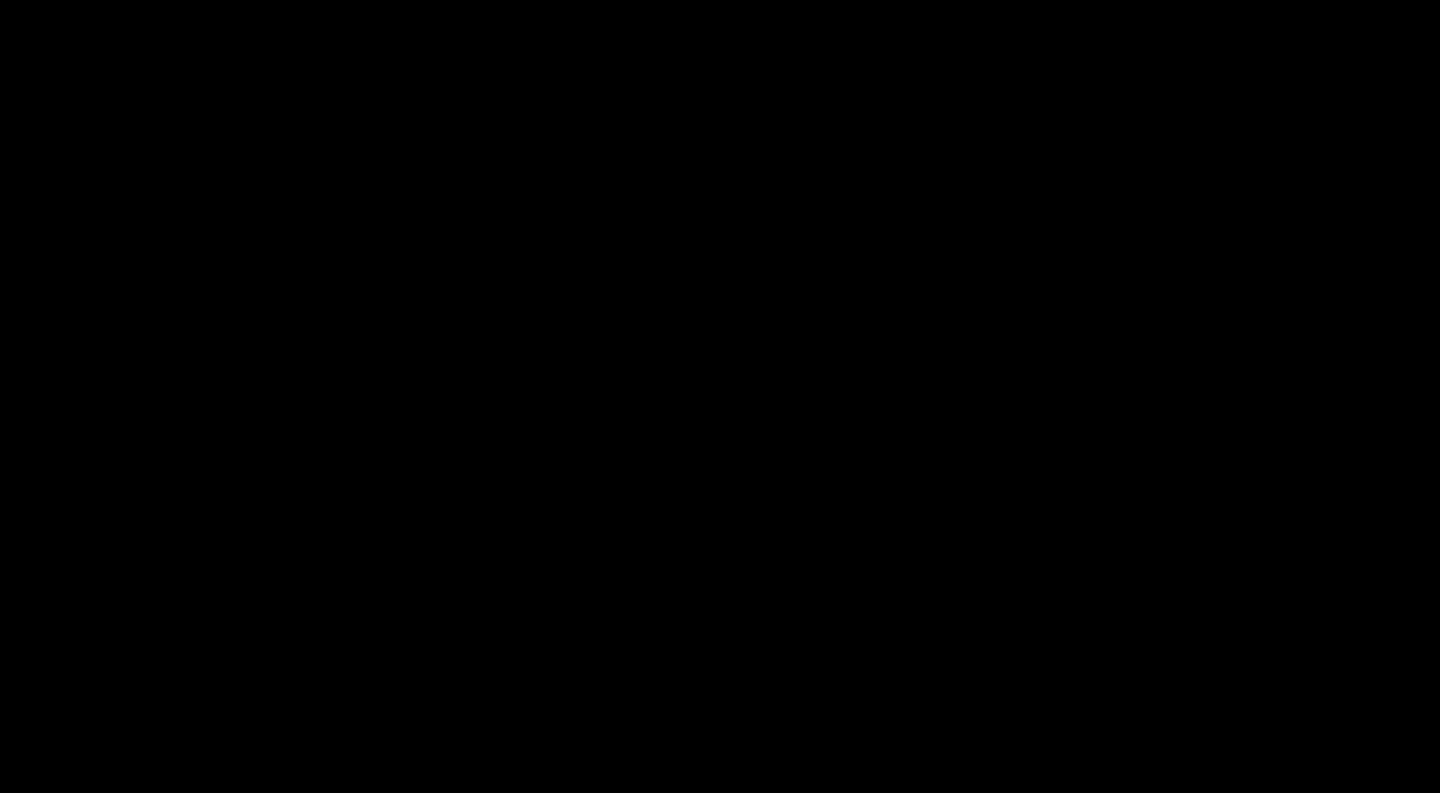
Some examples using STKO for post-processing



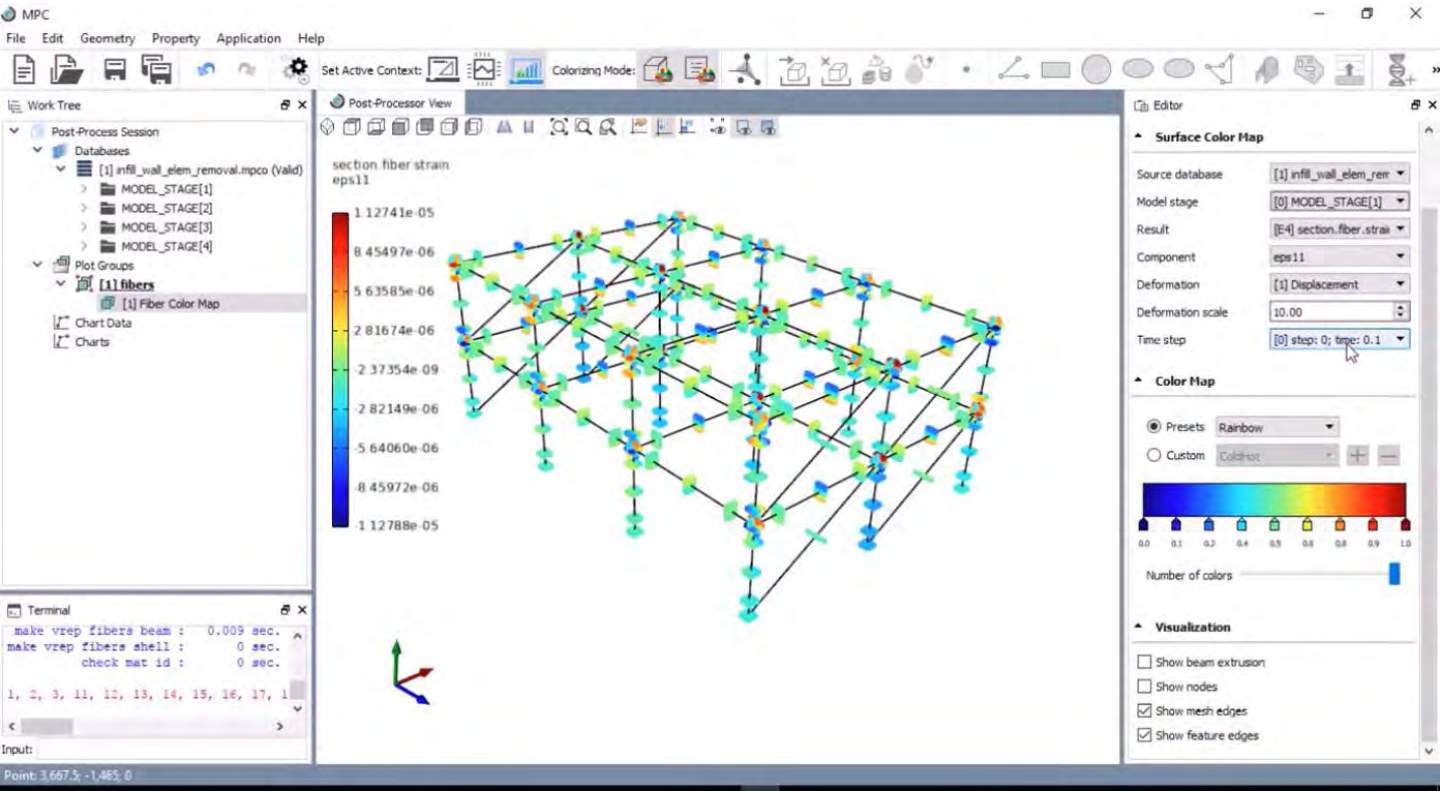
Example of Soil-Foundation-Structure-Interaction



Visualization of frame elements, gauss plot and fiber plot



Visualization of shell elements, gauss plot and fiber plot



Element removal, fiber plot, chart data extraction

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Conclusions

- HDF5 hierarchical structure is well suited for storing complex data
- A proper layout of complex data allows for advanced visualization tools such as fiber-section plot
- Future implementations
  - Parallel IO: now MPCORecorder works with OpenSees and OpenSeesMP (via partitioned databases), not with OpenSeesSP
  - Get local axes info from OpenSees

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Thanks!

Any questions ?

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Credits

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- Presentation template by SlidesCarnival
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