Inner warm membrane and plans for testing structural components

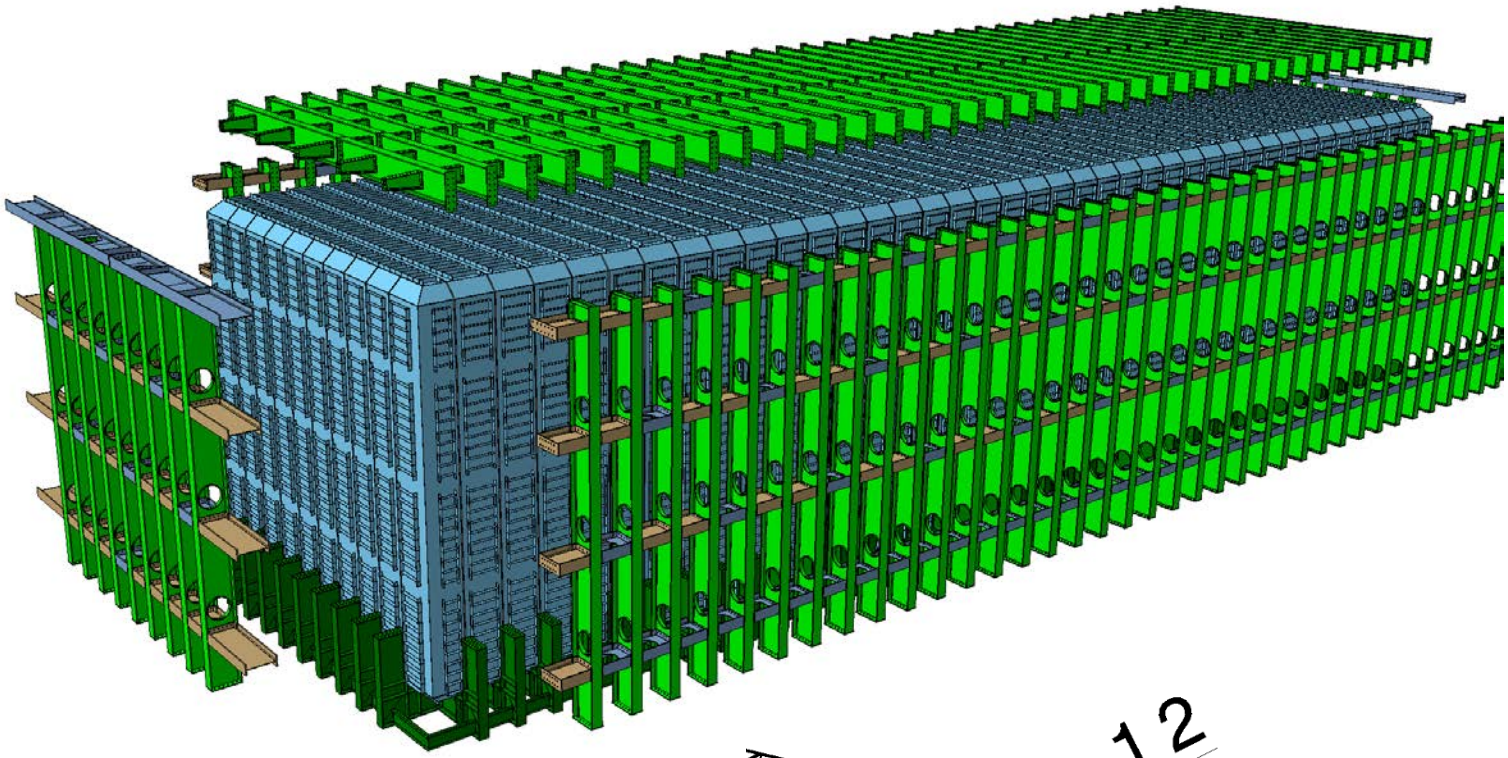
Luca D'Angelo

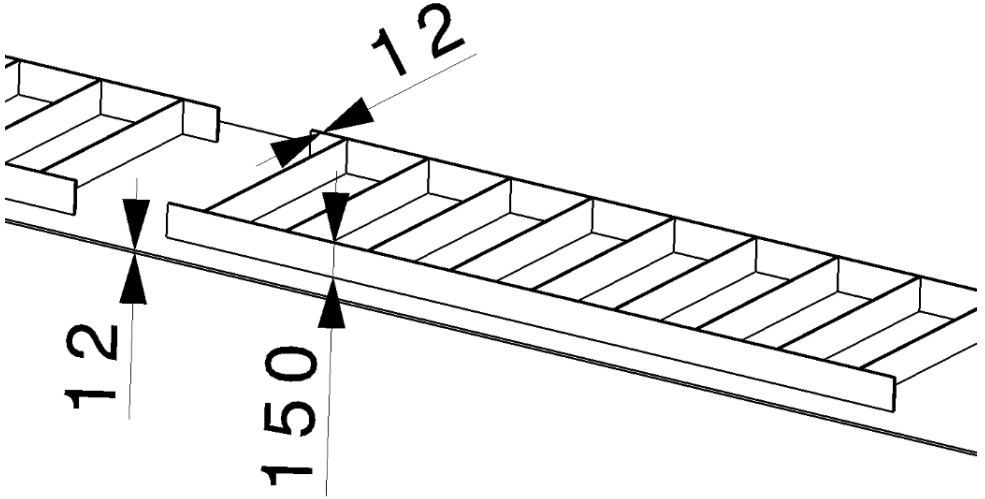
CERN EP-DT-EO

LBNF Discussion

CERN, 5th & 6th of December 2016

Reinforced Warm Membrane Concept





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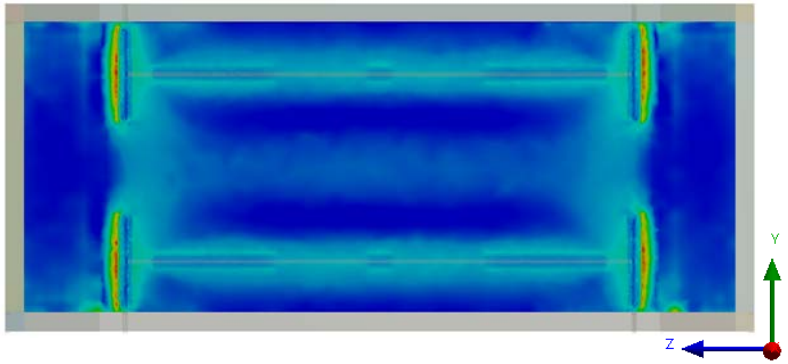
2. Linear buckling analysis
3. Connection plate-beams: clamping system
4. Plans for testing structural joints

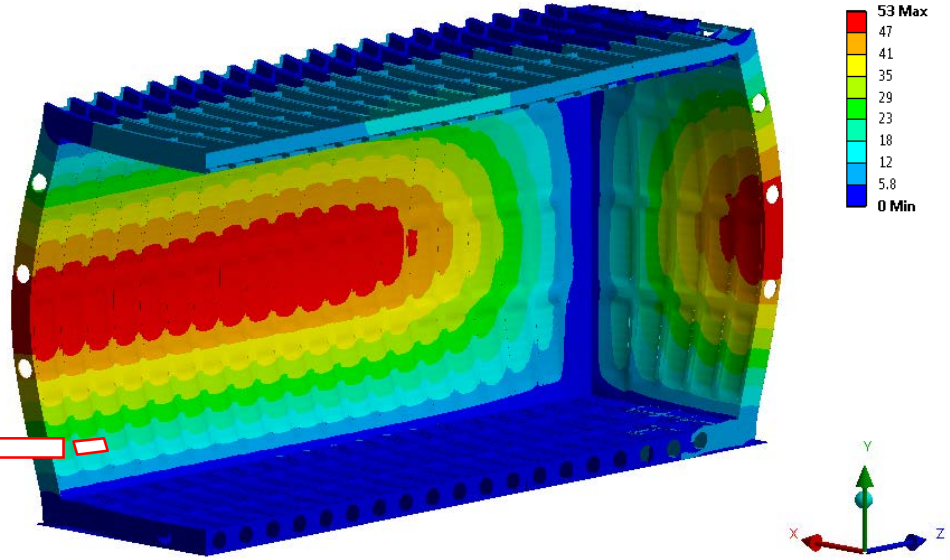
Stress analysis of the warm membrane

Nominal loads multiplied by γ partial factors are used to compute Von Mises stresses in the plate

VON MISES STRESSES: IN RED $\sigma_{VM} > f_Y/1.1$



Sub-model of the plate [1.6 x 0.7 m]



Global FEA model of ¼ of cryostat

In all ribs σ_{VM} << design yield strength $f_Y/1.1$

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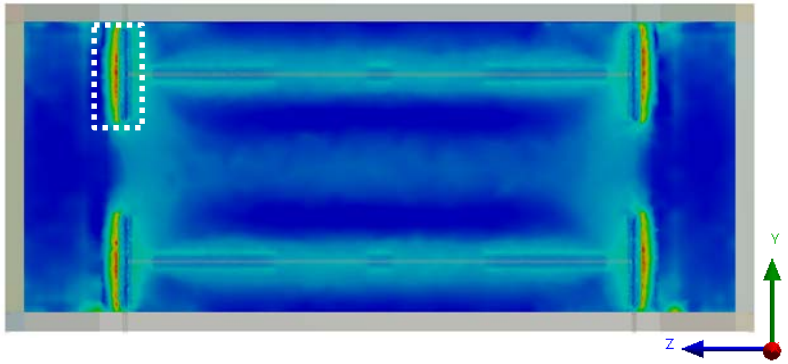

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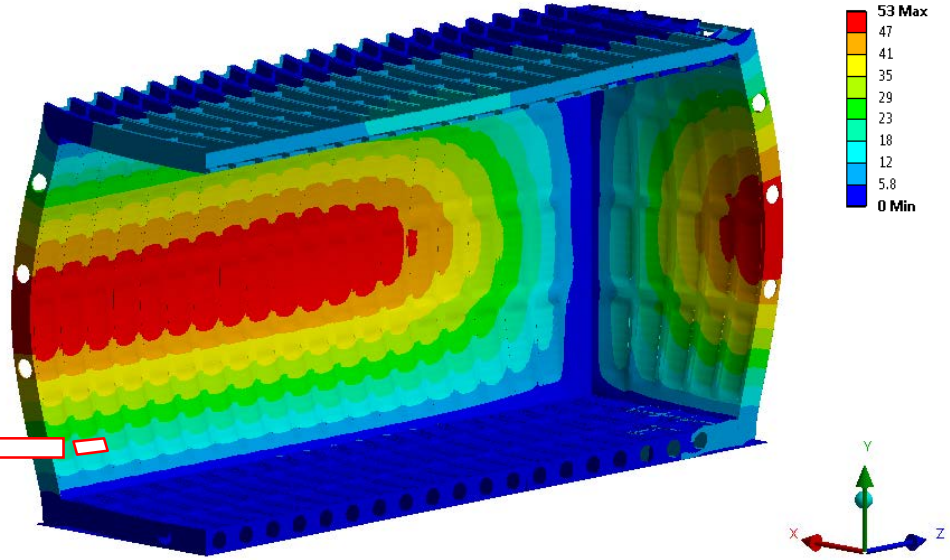

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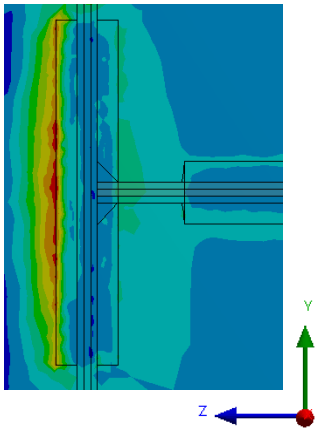
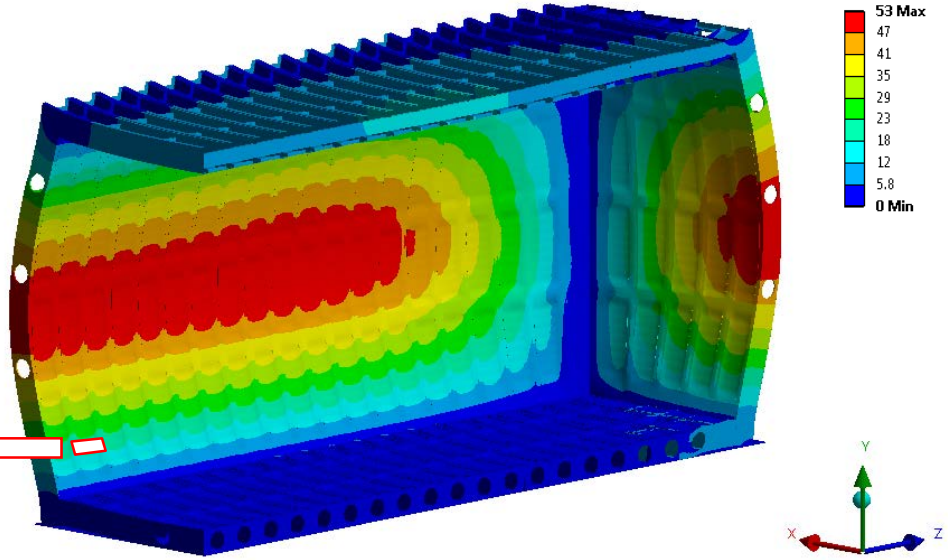


Zoom of the interface weld/plate



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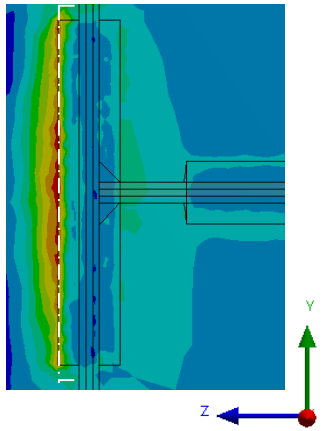

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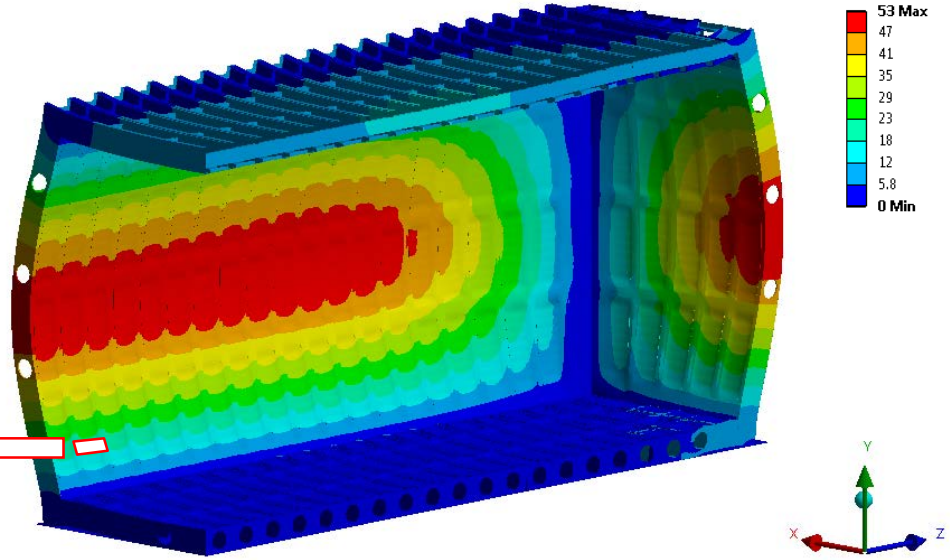

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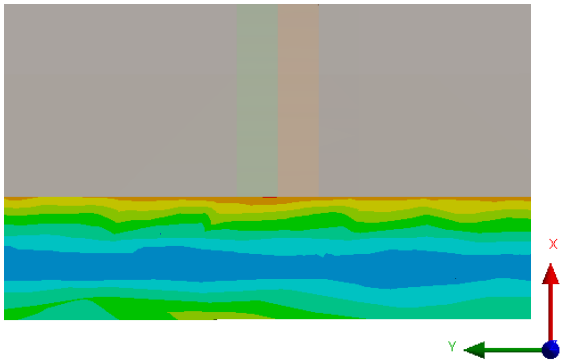
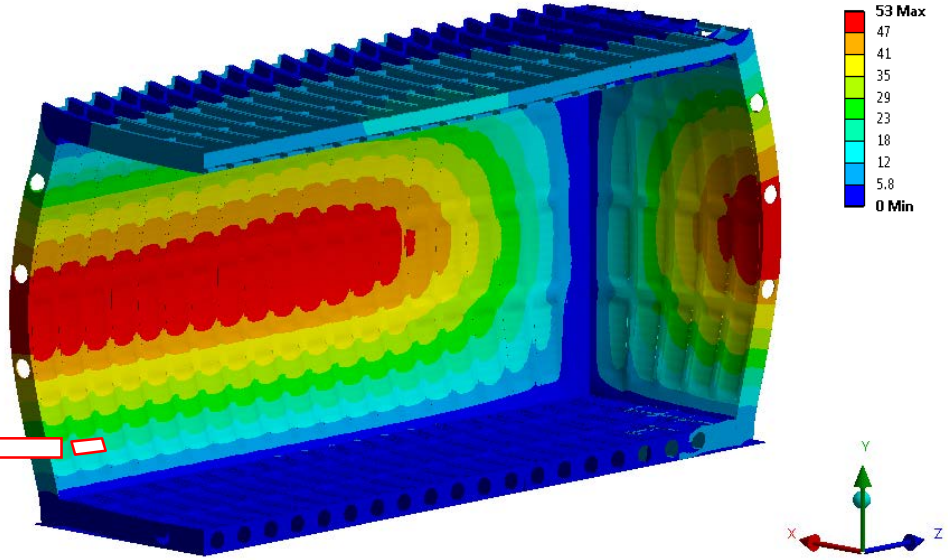


Section of the plate



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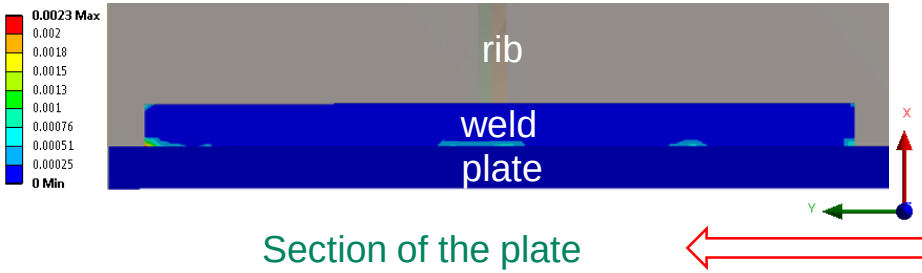
ELASTO-PLASTIC ANALYSIS
Equivalent plastic strain: max = 0.23%



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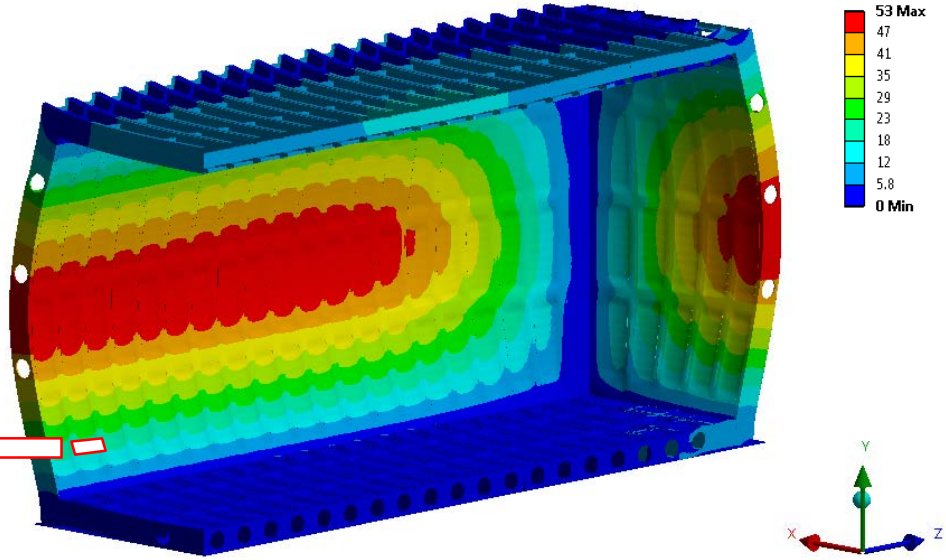

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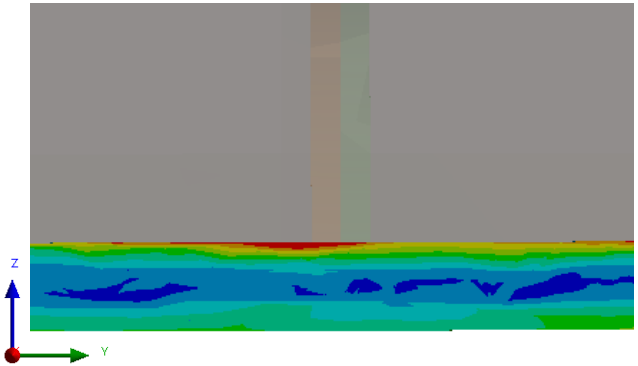
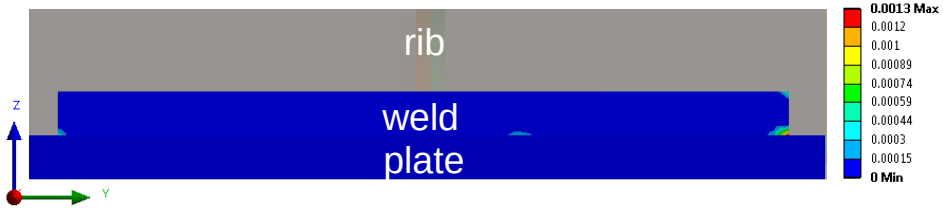
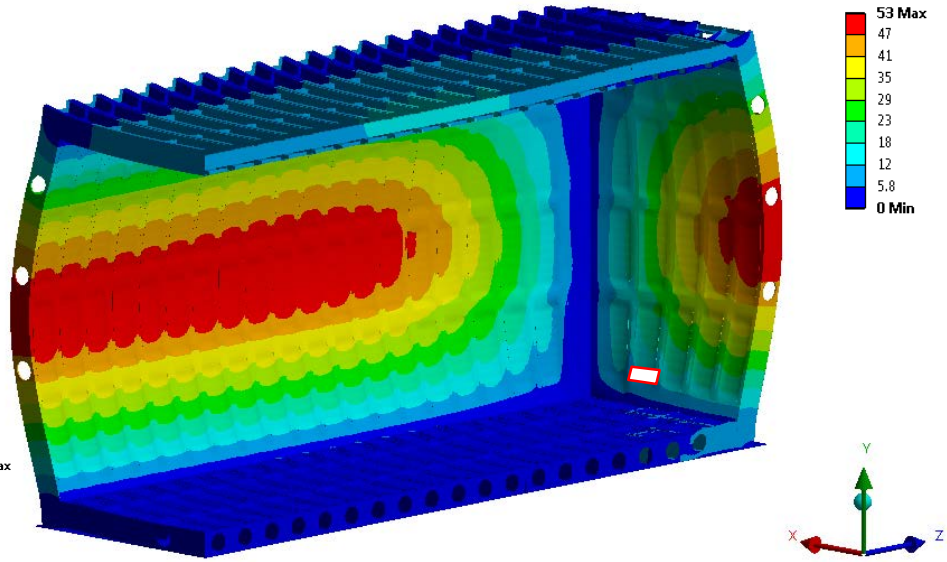


ELASTO-PLASTIC ANALYSIS
Equivalent plastic strain: max = 0.13%



Section of the plate



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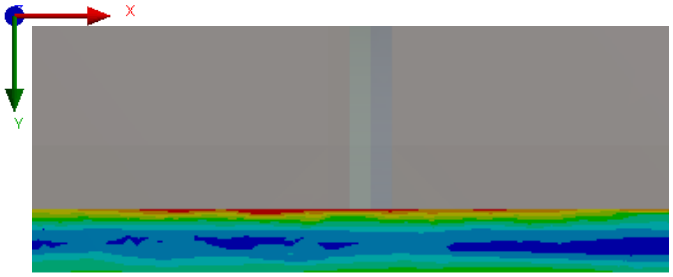
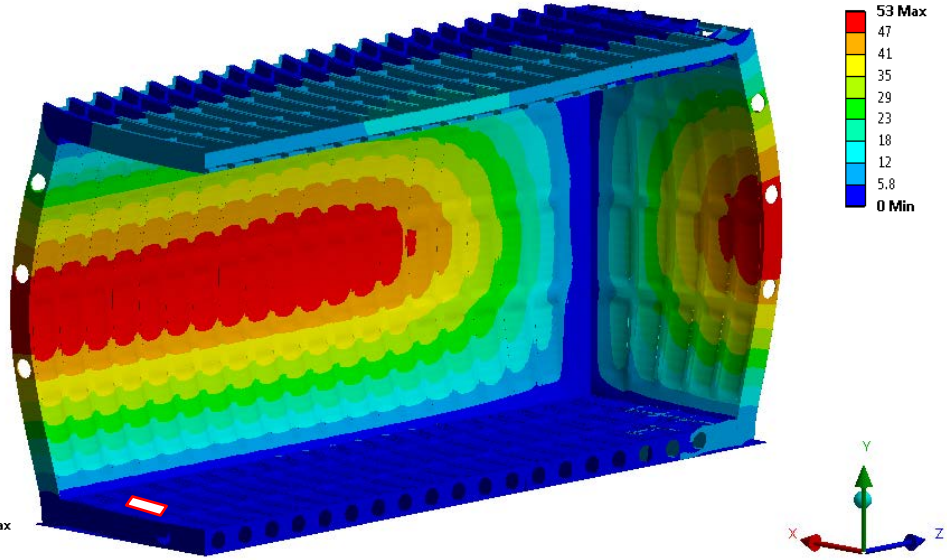
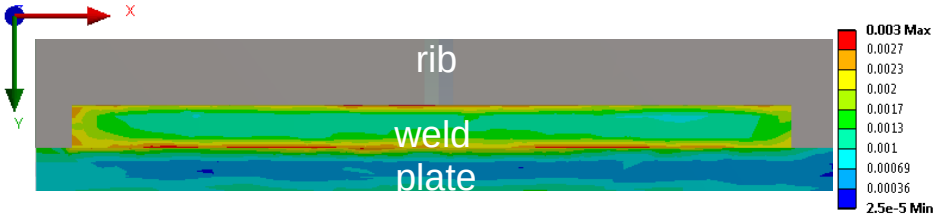


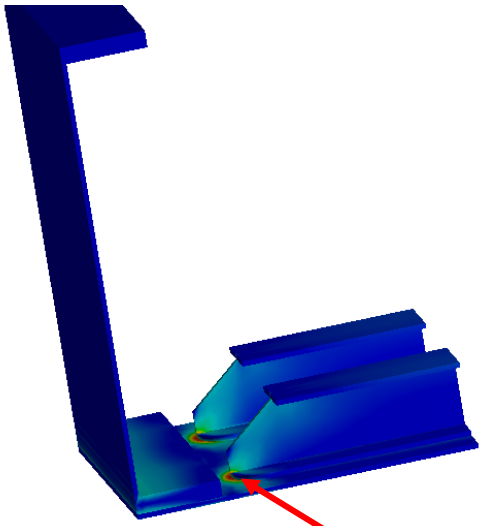


Global FEA model of ¼ of cryostat

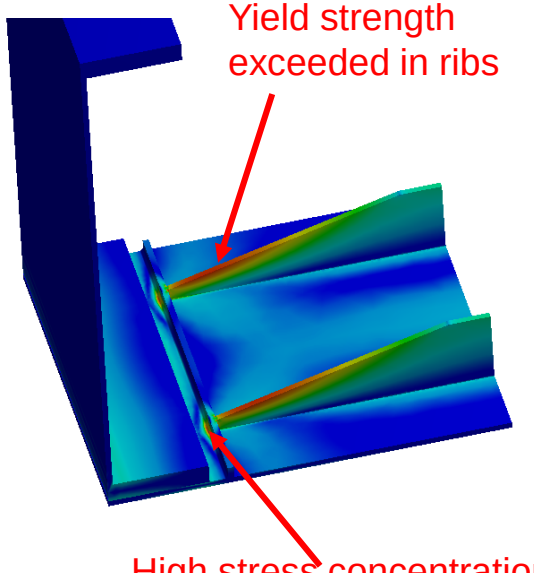
ELASTO-PLASTIC ANALYSIS
Equivalent plastic strain: max = 0.3%



Other concepts of reinforced membrane

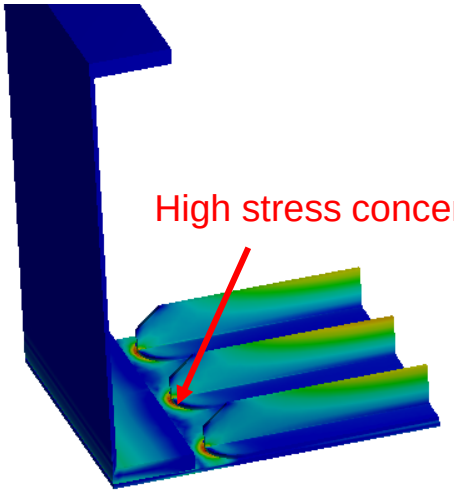


High stress concentration



Yield strength exceeded in ribs

High stress concentration



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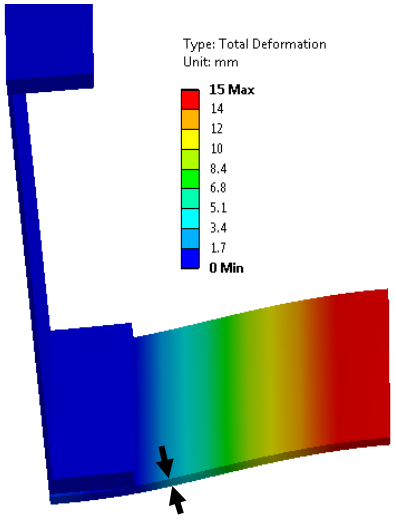


Not acceptable:
From ~3mm to ~15mm

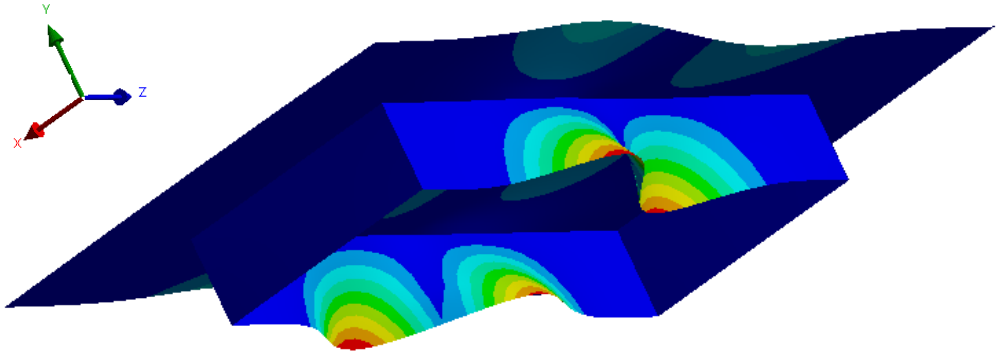
24mm plate

Linear Buckling Analysis

Unit cell (1.6 x 0.7 m) at the center of the floor of the vessel is analysed. Maximum hydrostatic pressure value is used.

Mode	Load Multiplier
1	-9.04
2	-9.05
3	-9.19
4	-9.21
5	-12.09
6	-12.23
7	-12.40
8	-12.52
9	-15.94
10	-16.21

First eigenmode

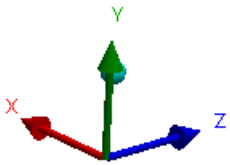


First 10 eigenvalues are negative and all refer to instability of ribs for reversed pressure.

For current loading conditions there is no risk of later-torsional buckling of ribs

Connection plate-beams

Warm plate is connected to the frame by using a clamping system, which allows for relative in-plane displacements between the plate and the beams



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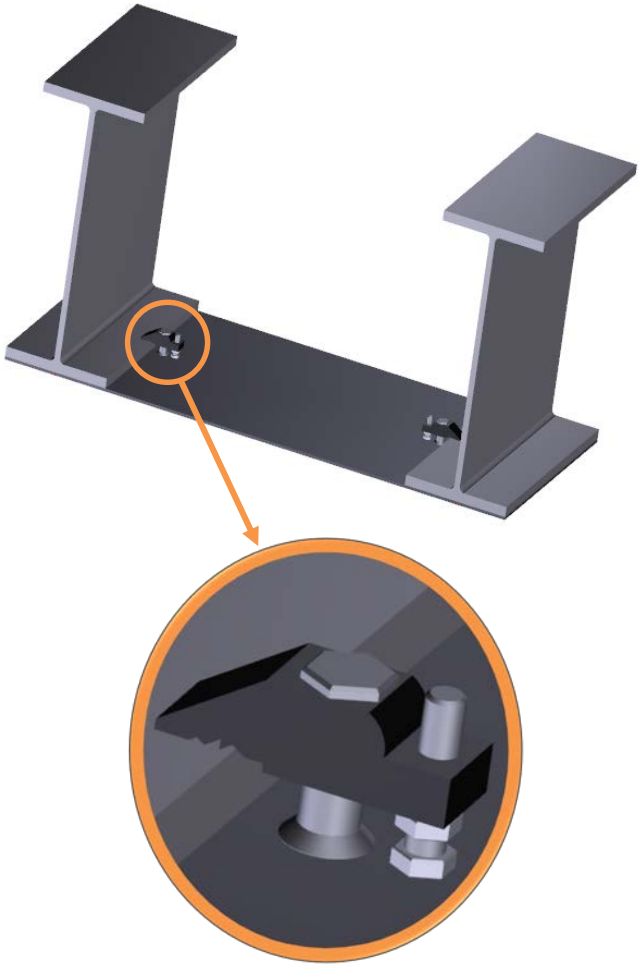
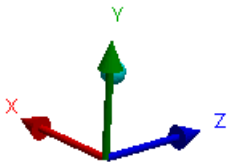
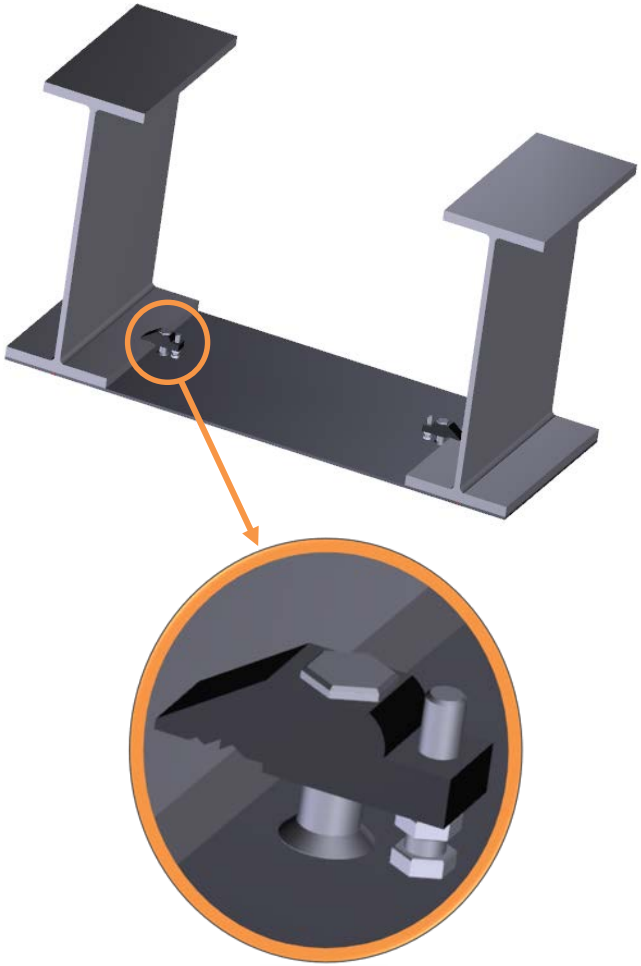


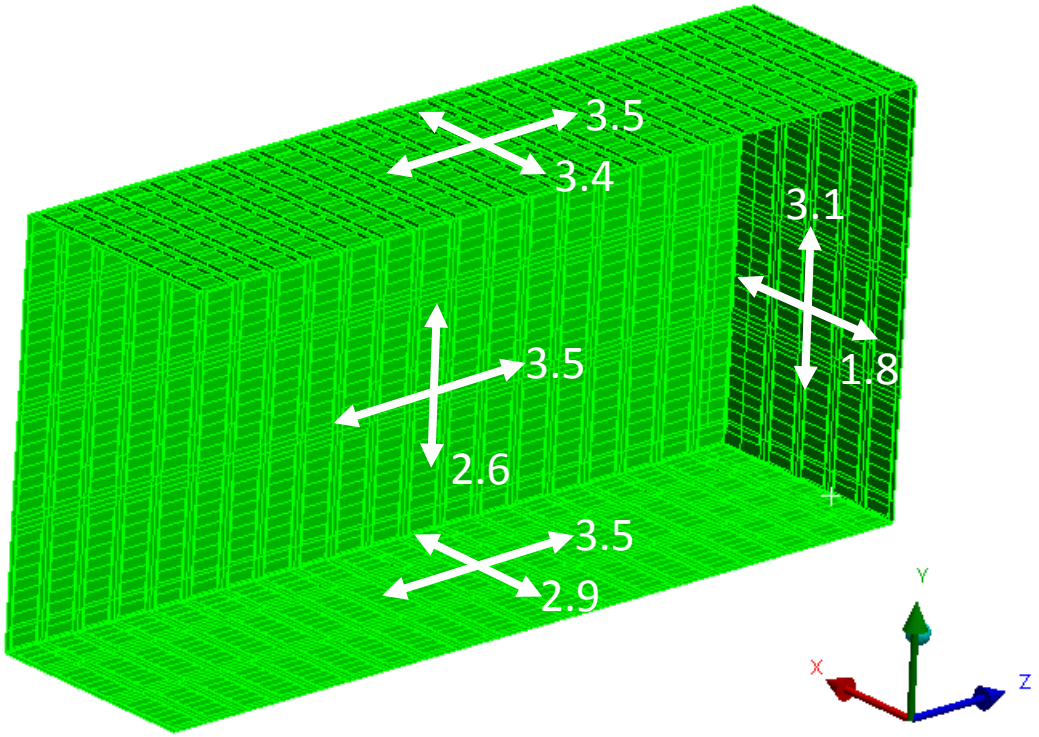


Connection plate-beams

Warm membrane is connected to the frame by using a clamping system, which allows for relative in-plane displacements between the membrane and the beams



Maximum relative displacements [mm]



Plans for testing structural joints

- Collaboration with EPFL RessLab (former Steel Structures Lab)
- Tests will be carried out at EPFL Structural Hall
- 2’000 kN actuators are available

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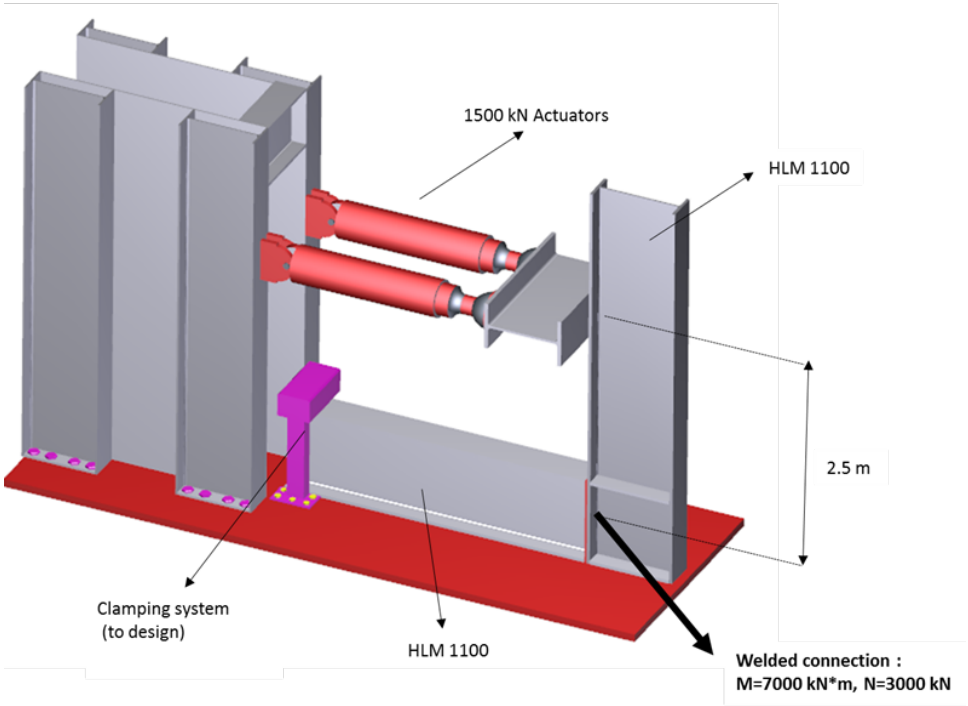

Bottom Corner

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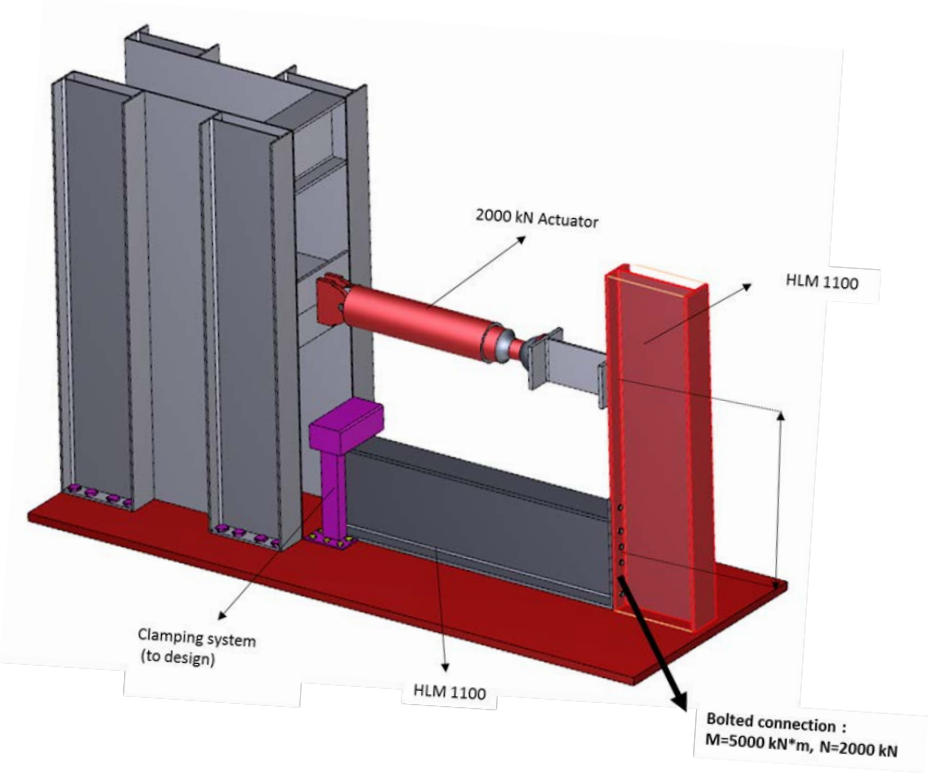

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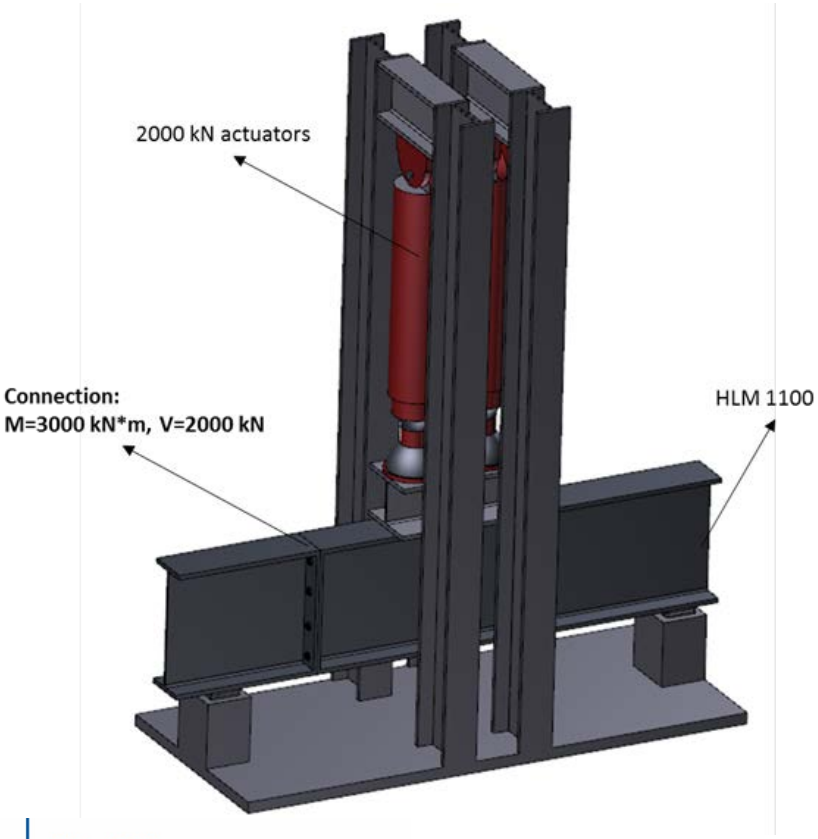

Splice

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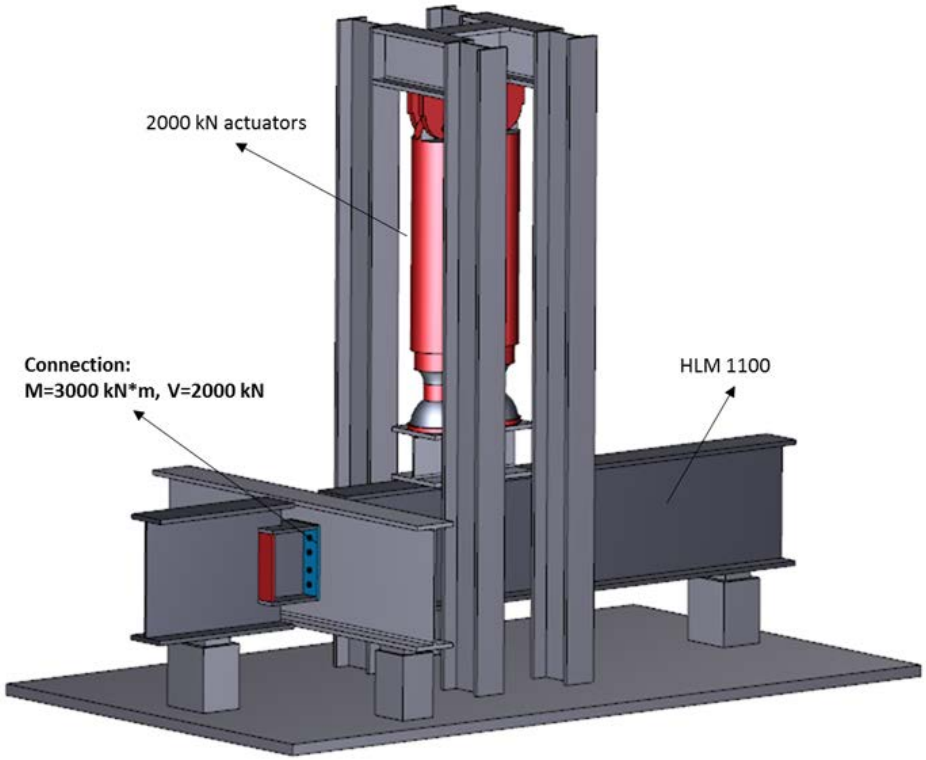

Belt/Column connection