SOLEXPERTS
Swiss Precision Geomonitoring

hiDCon - high Deformable Concrete
an overview of projects

Patrick Steiner





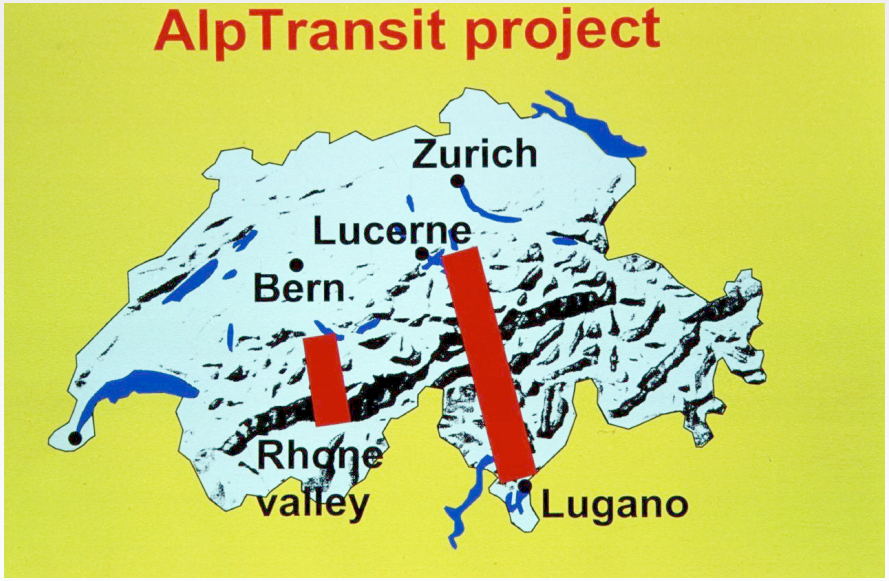


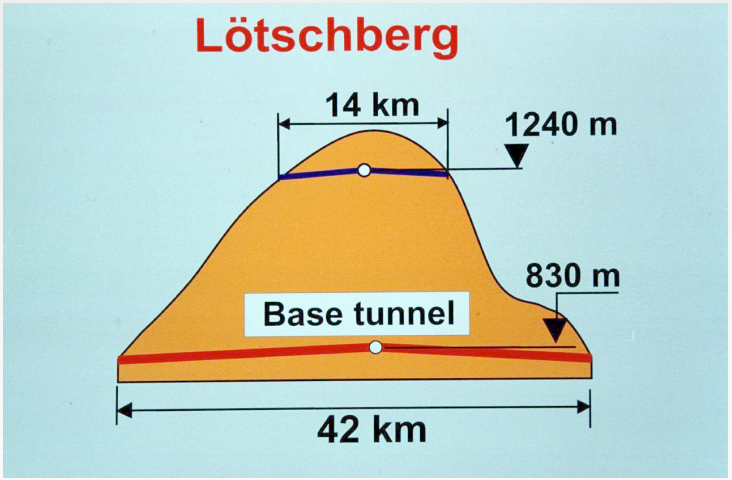


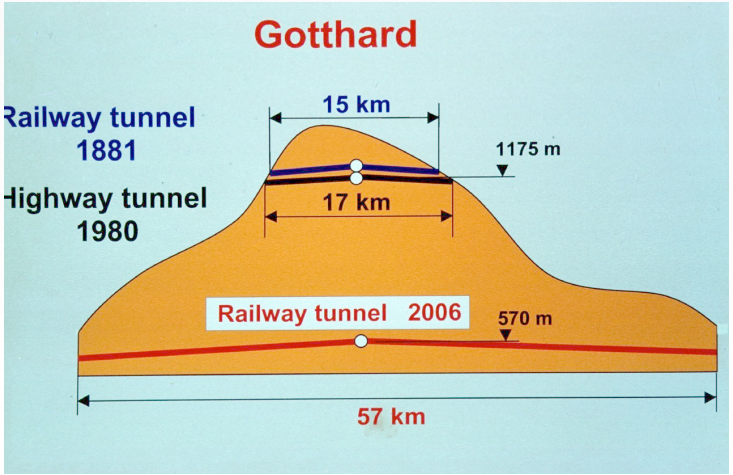


- history and background
- hiDCon - Elements
  - Yielding elements for shotcrete support
  - Modular Yielding Support
- Compressible intermediate layer
  - hiDCon-F
- NEW: hiDSte

► history





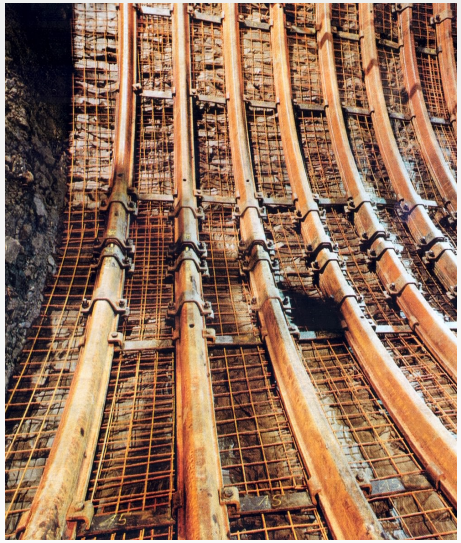


- high overburden
- difficult rock, water and soil conditions
- squeezing ground expected
- …

history

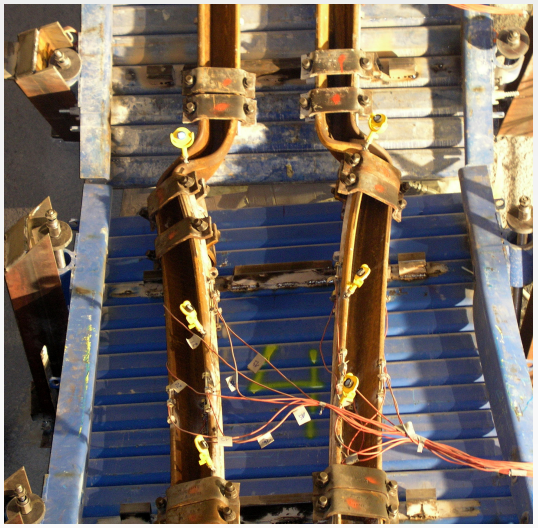
Situation

history



Mining experience → Adaption to tunnelling → Proof of concept 1:1 scale

history

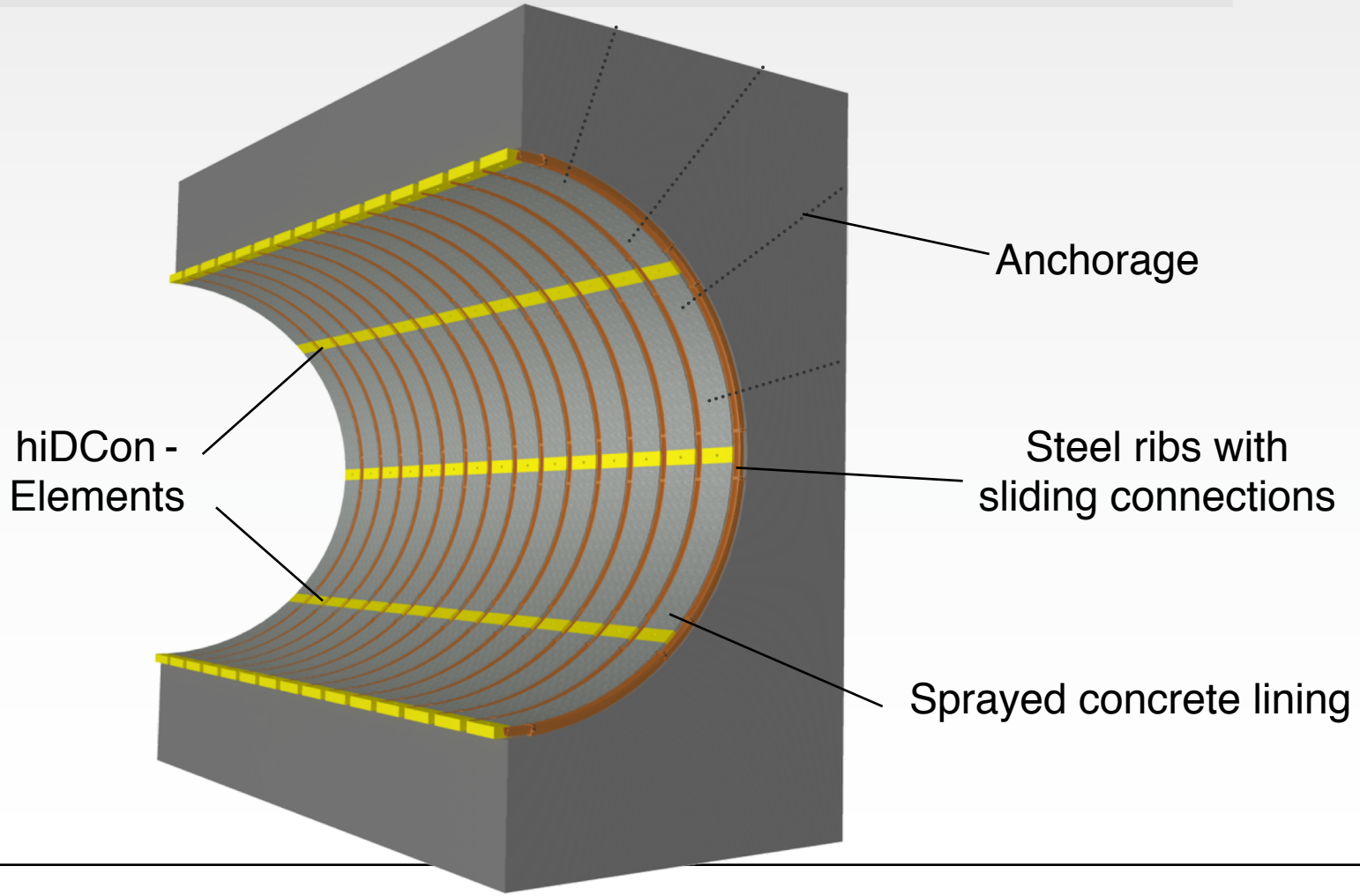


The 1:1 scale tests showed that a system of TH profiles is working, but the load capacity of the system is significantly lower than expected.

→ **Improving the load – deformation capacity of the lining system by using the shotcrete shell with in cooperated deformable elements**

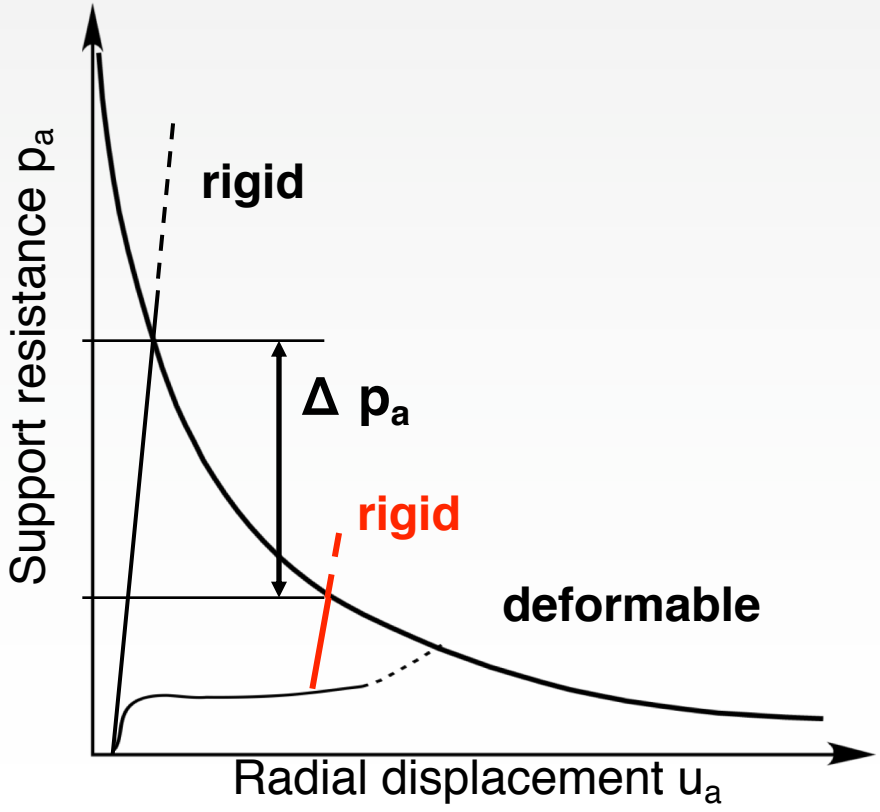
background

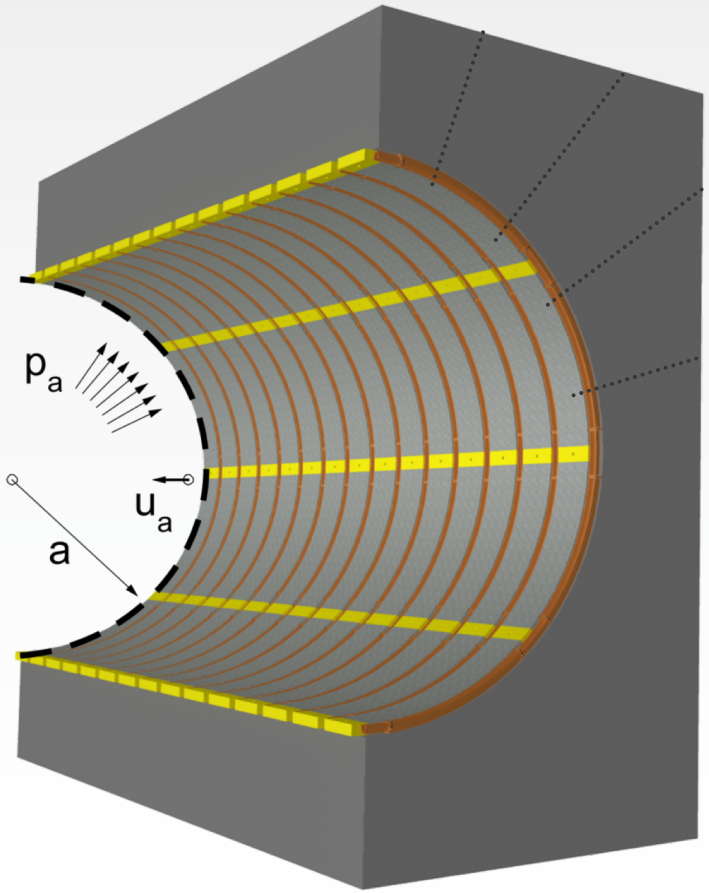
Principle



background

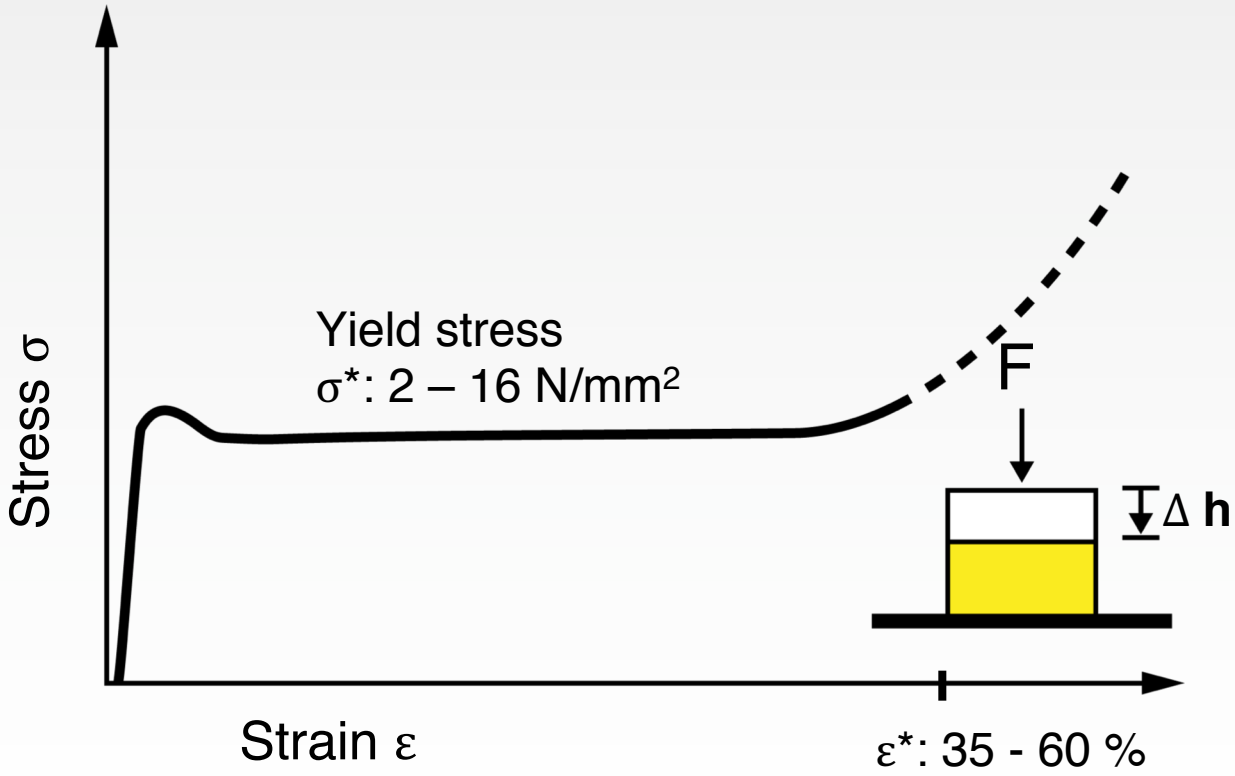
Support resistance





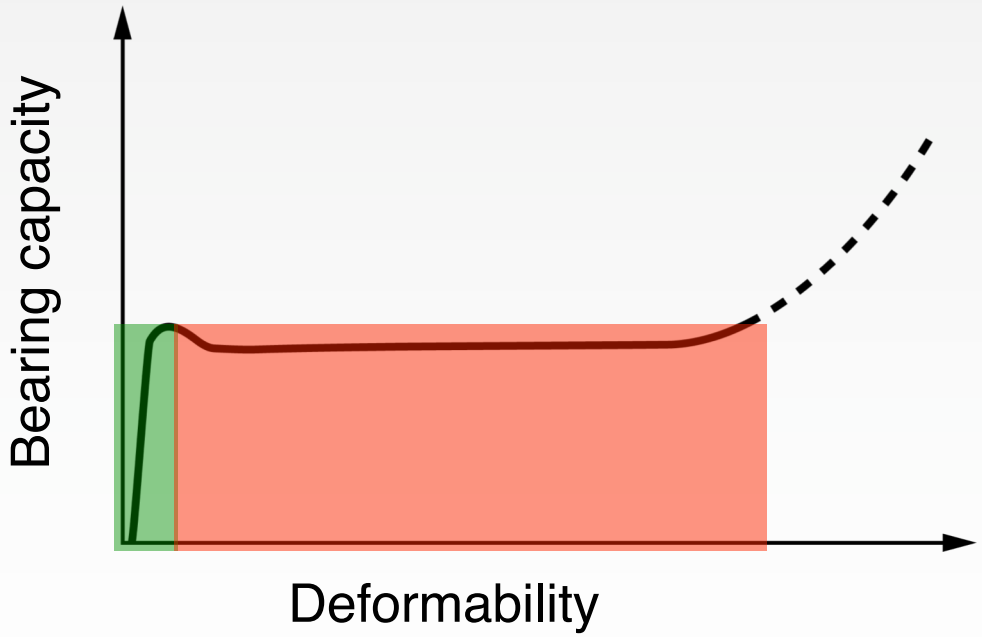
► hiDCon - Elements

Material properties



hiDCon - Elements

Control of the element properties



Bearing capacity

- Cement (Type)
- Cement (Ratio)
- Water ratio
- Aggregates
- Concrete admixtures
- Reinforcement

Deformability

- Air space ratio
- Grading line
- Steel fibre
- Type of reinforcement
- Geometry
- Concrete admixtures

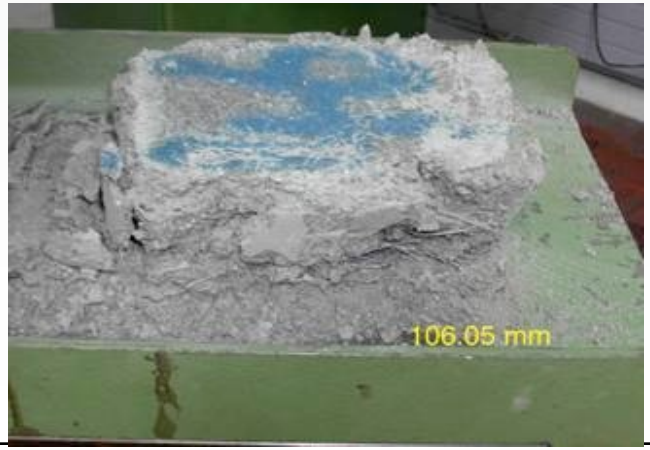
► hiDCon - Elements

Properties

- **High deformation capacity under nearly constant load resistance**
- **Increasing load resistance at the end of deformation capacity**
- **Variability of shape and dimension**
- **Control of bearing and deformation properties**
- **Application of approved base materials**
- **Insignificant creeping under constant longtime loading**

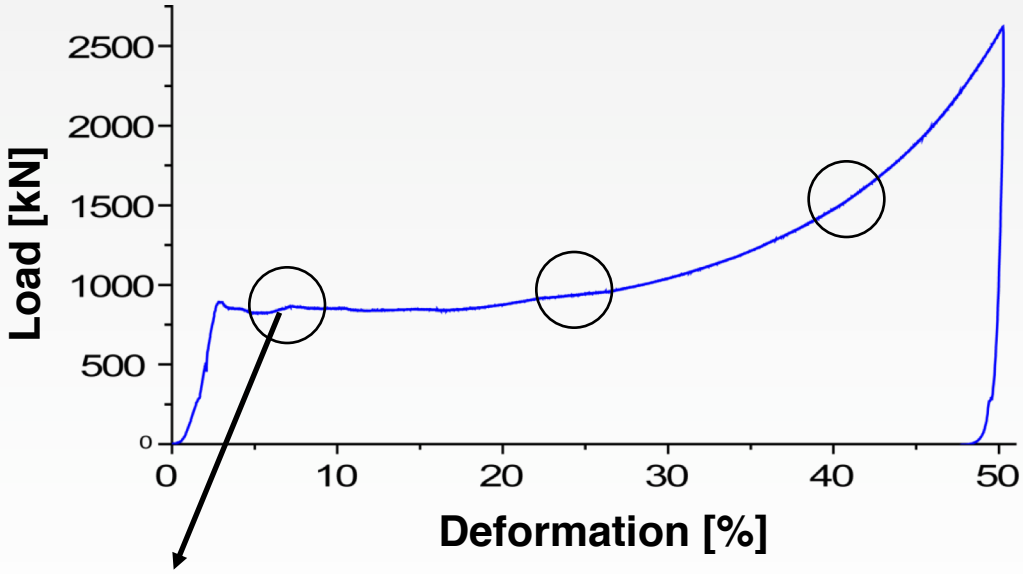
► hiDCon - Elements

Uniaxial compression test



hiDCon - Elements

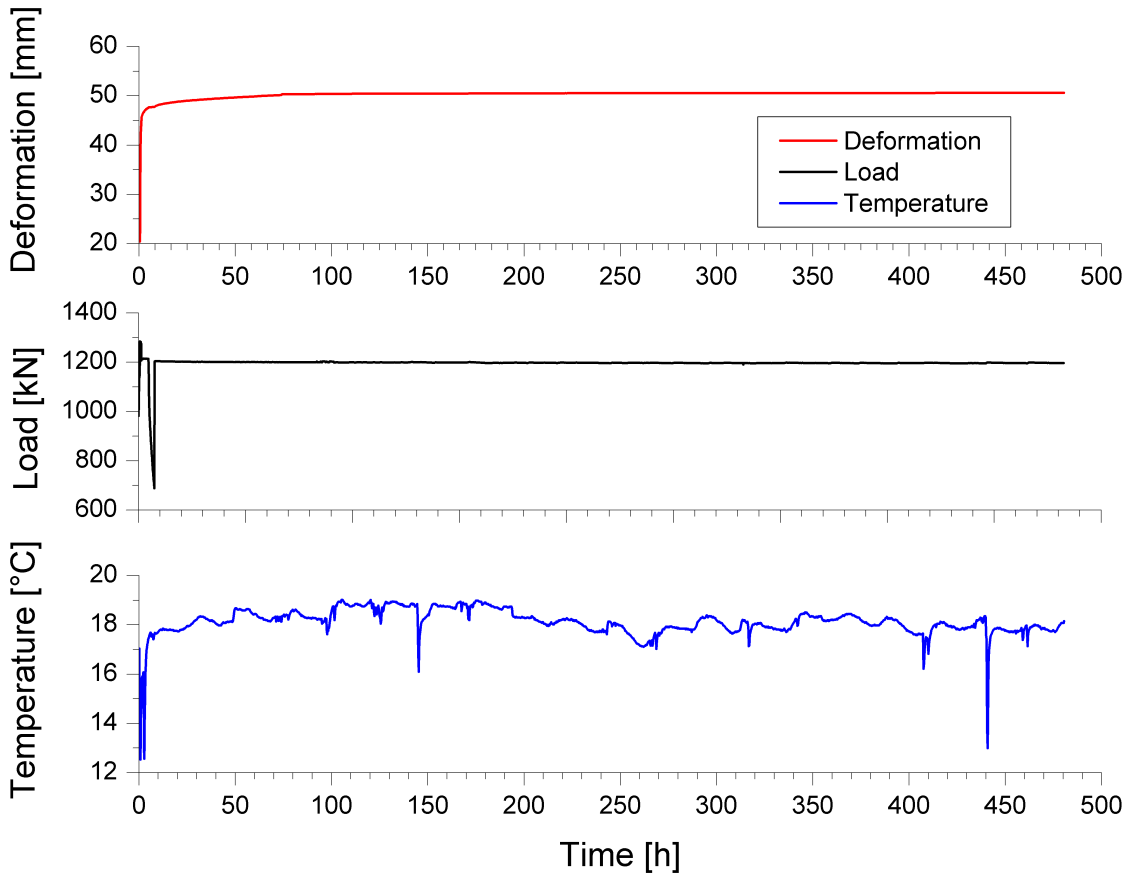
Creep properties under longtime loading



Creep test:
Constant Load

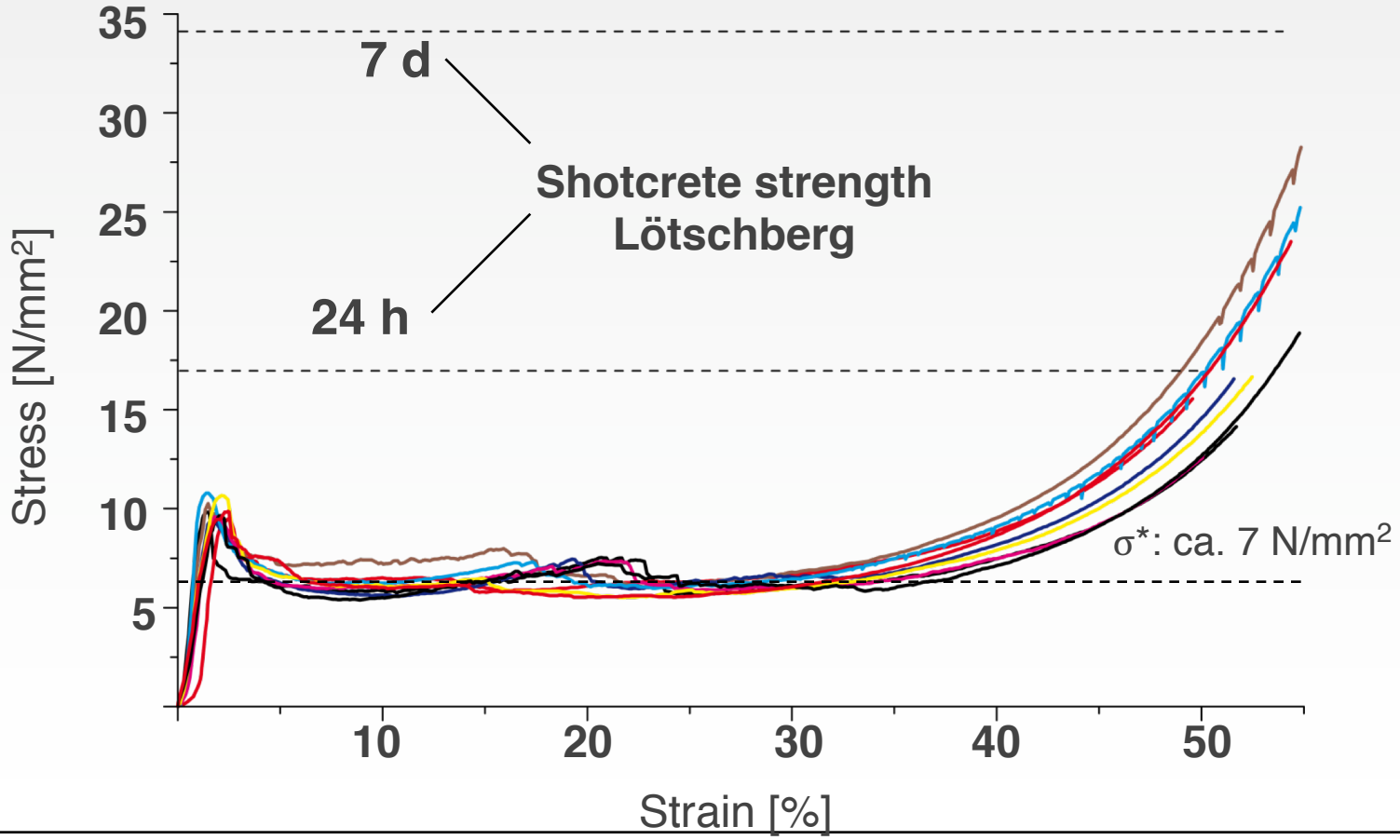
hiDCon - Elements

Creep properties under longtime loading



Yielding elements for shotcrete support

hiDCon – beam shaped element



► Applications

2004 the first tunnel support system was equipped with SOLEXPERTS's high deformable concrete elements hiDCon.
Beam elements are incorporated in the shotcrete lining for rock support and allowing tunnel convergence at the same time.
Since then hiDCon elements have been further developed and a number of applications in squeezing and swelling ground could be realized. The major projects are:

- Lötschberg Base Tunnel (Switzerland); (squeezing rock)
- LTF Base Tunnel, Access Gallery St. Martin la Porte (France); (squeezing rock)
- Chienberg Road Tunnel (Switzerland); (swelling rock)
- Praclay experiment – HADES underground rock lab (Belgium); (compensation of thermal expansion)
- Bure, ANDRA underground rock lab (France) (long term squeezing induced by swelling)
- Cigar Lake Mine (Canada); (squeezing induced by ground freezing)

Yielding elements for shotcrete support

Application: Lötschberg base tunnel

Yielding elements for shotcrete support

Application: Lötschberg base tunnel

Yielding elements for shotcrete support

Application: Access tunnel St. Martin la Porte (LTF)

Yielding elements for shotcrete support

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Yielding elements for shotcrete support

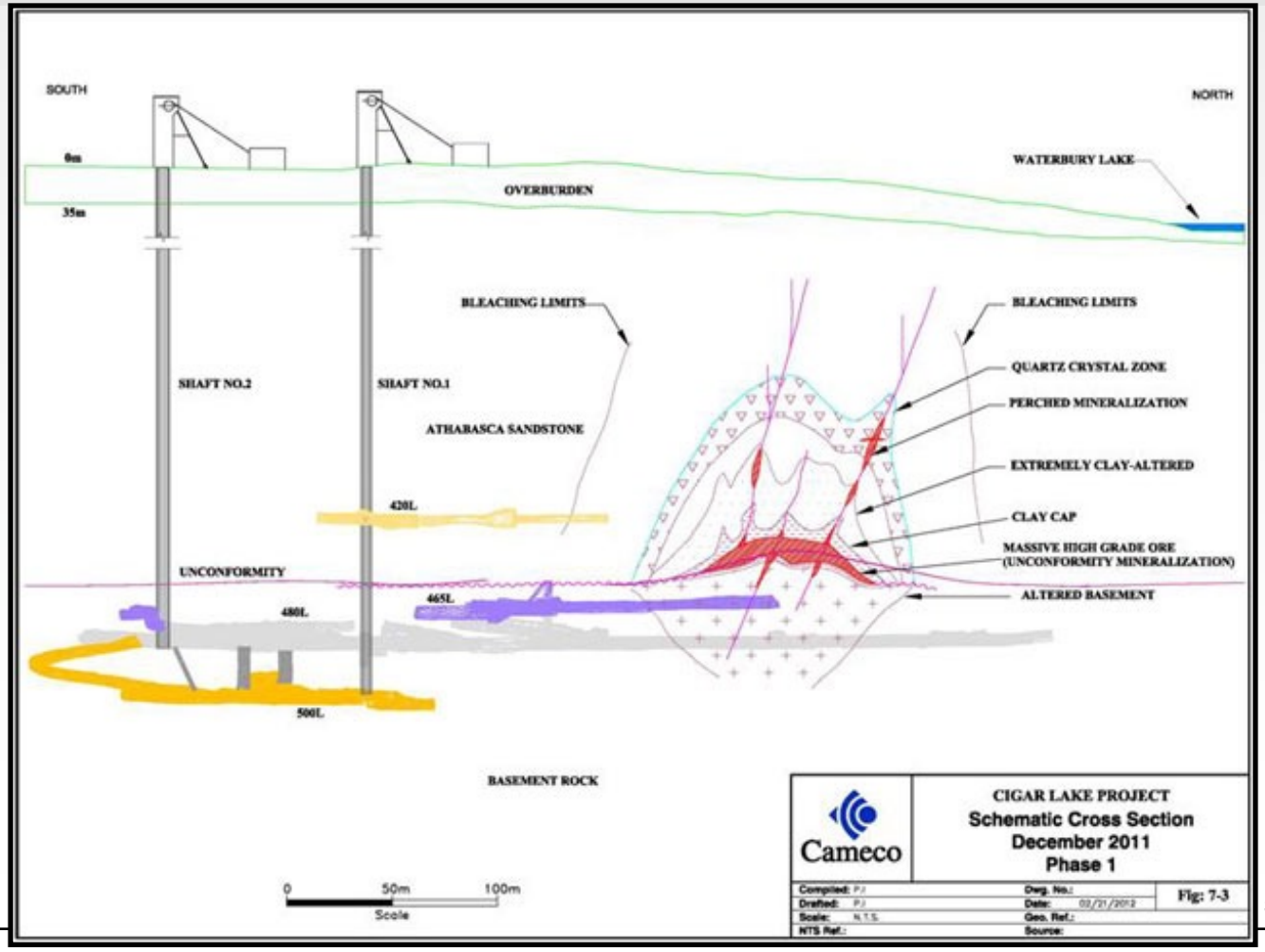
Application: Access tunnel St. Martin la Porte (LTF

Yielding elements for shotcrete support

Application: TELT

Yielding elements for shotcrete support

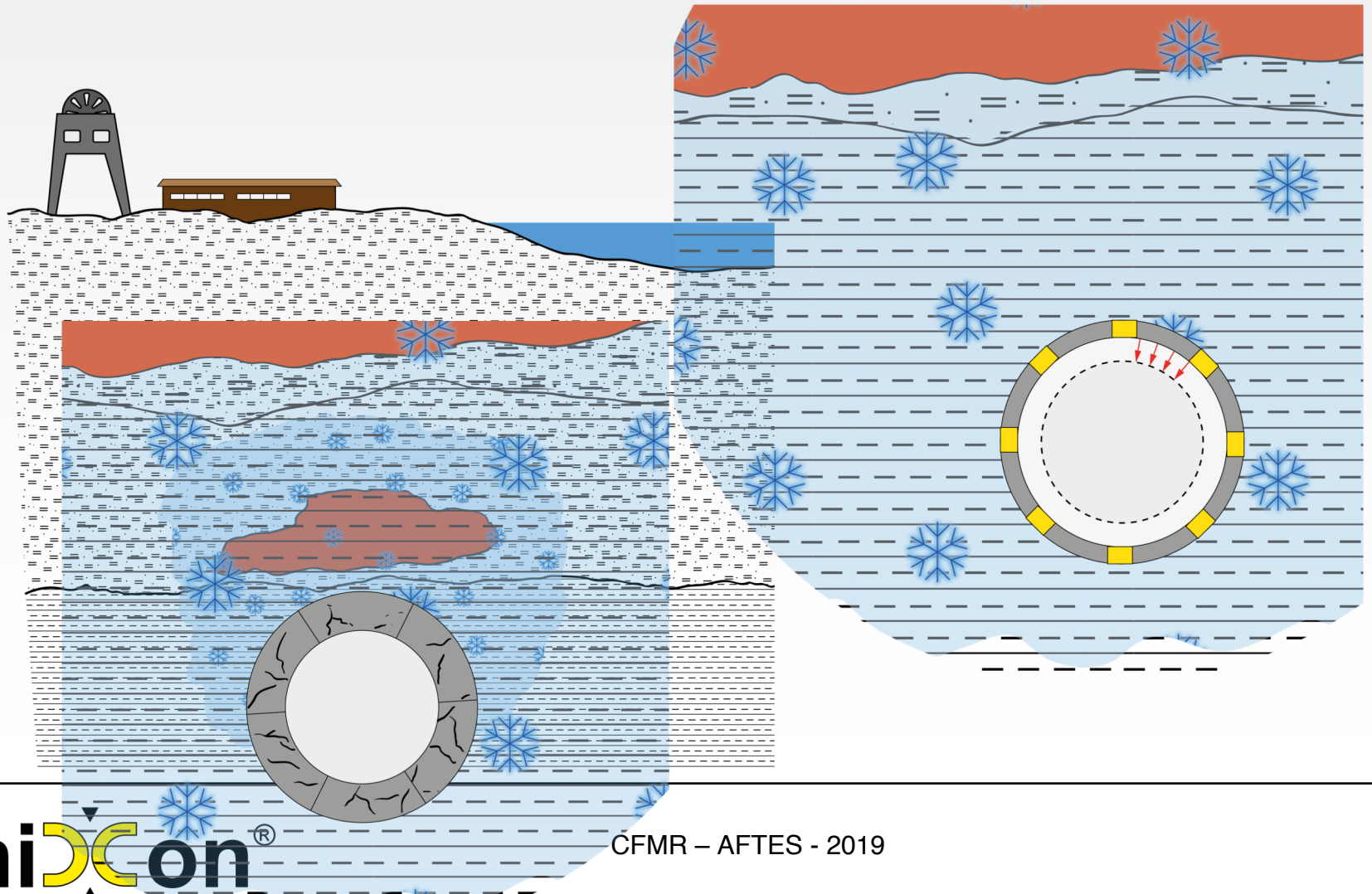
Application: Cigar Lake Mine



Source: Internet

Yielding elements for shotcrete support

Application: Cigar Lake Mine



Yielding elements for shotcrete support

Application: Cigar Lake Mine

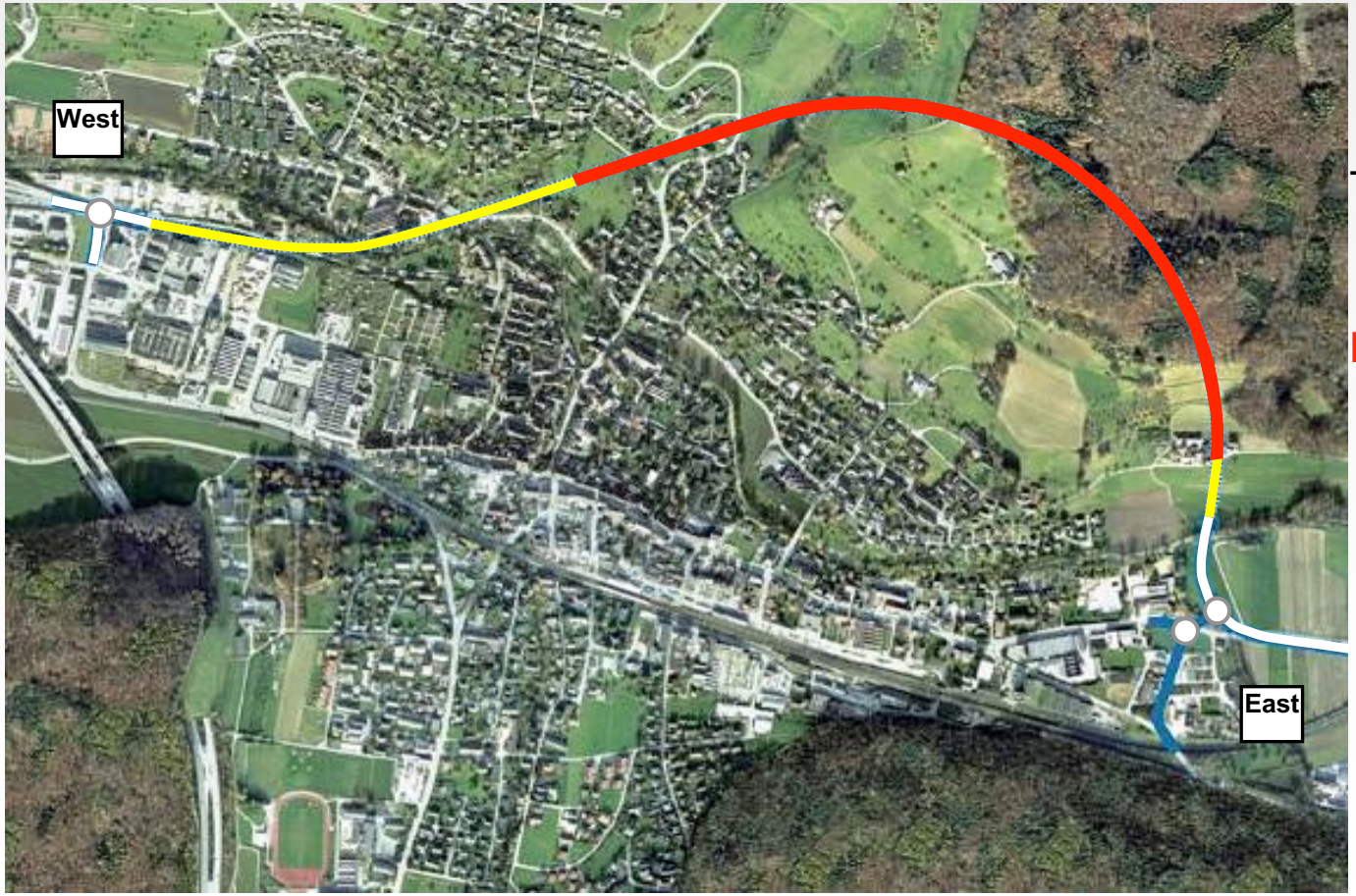
► Yielding elements for shotcrete support

Application: Cigar Lake Mine

Source: Internet

Modular Yielding Support

Chienberg road tunnel

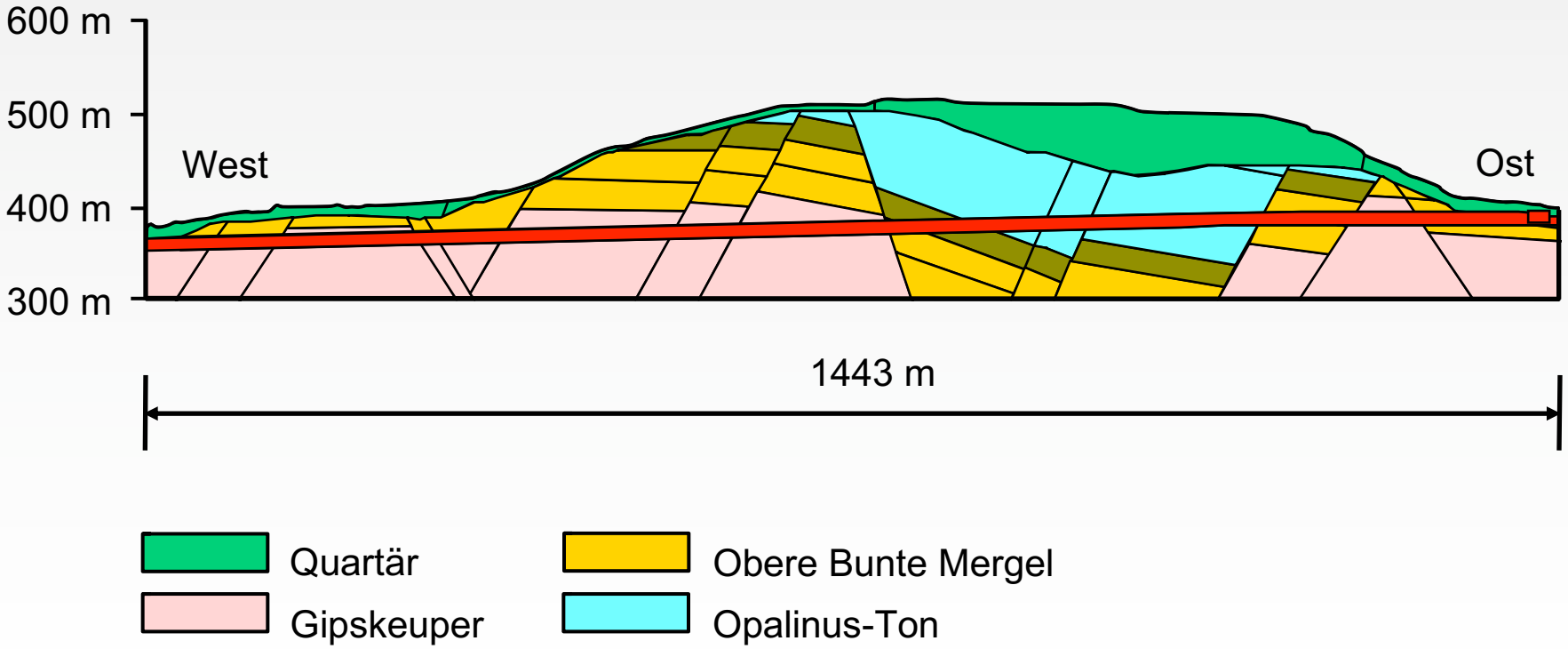


Total length: 2.3 km

Mining operation: 1.5 km

Modular Yielding Support

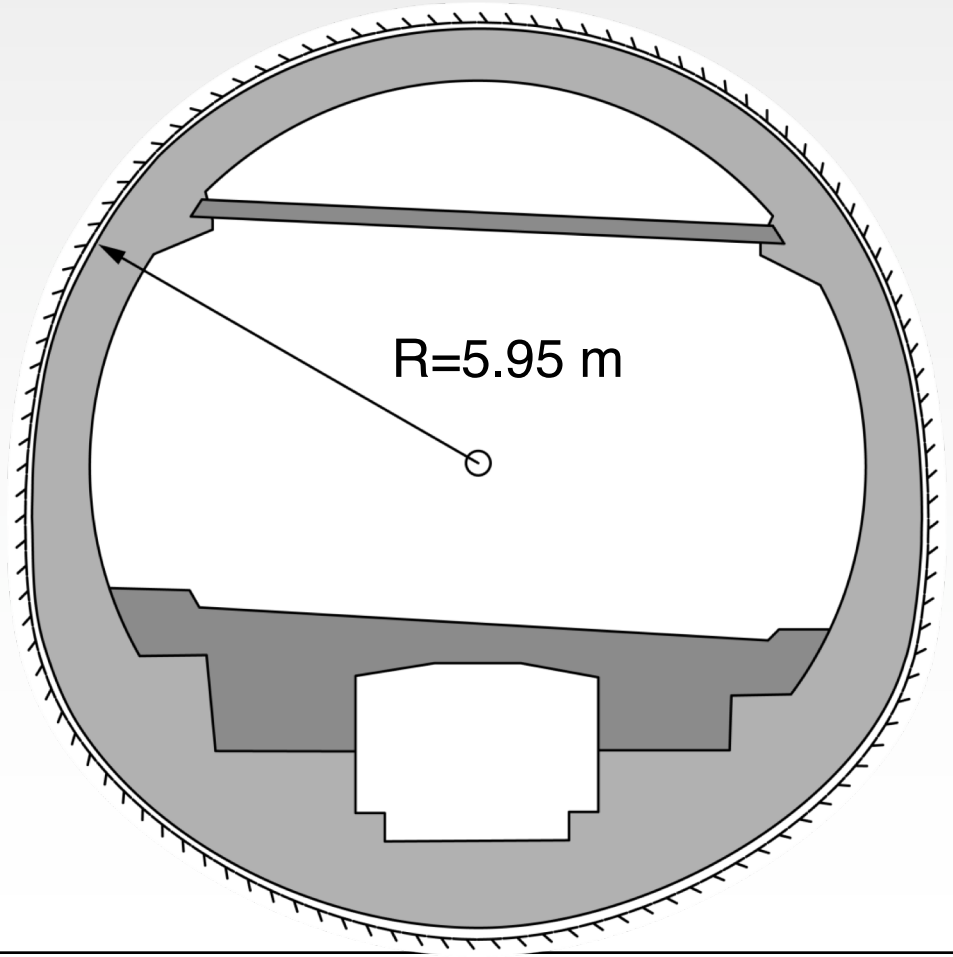
Geology



Quelle: Vortrag FGU‘07

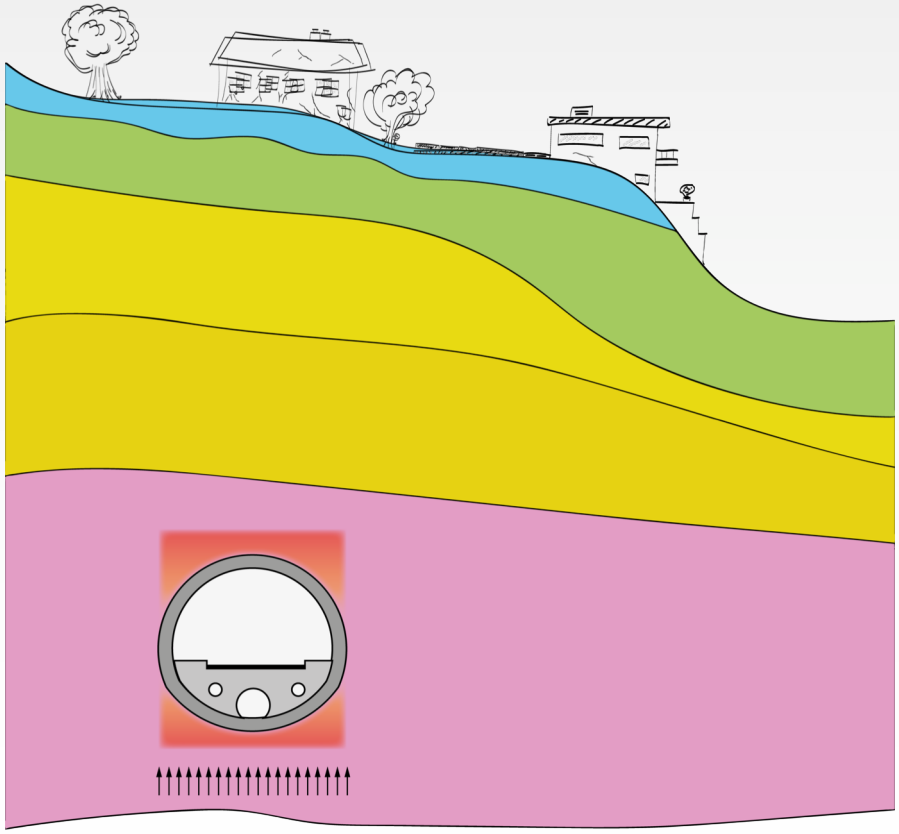
Modular Yielding Support

Cross section – resistance principle



Modular Yielding Support

resistance principle vs. reality

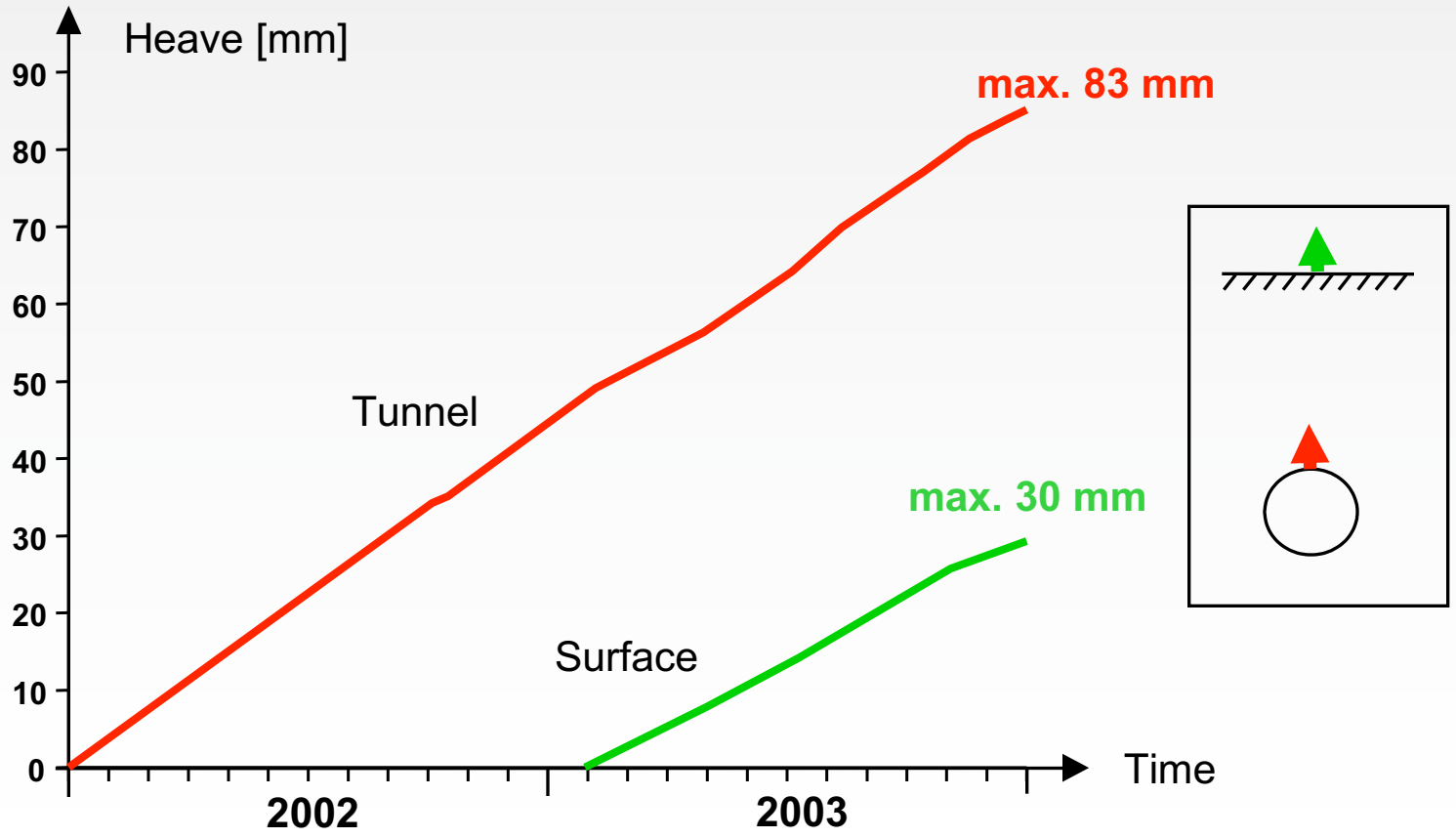


Modular Yielding Support

Bottom heave

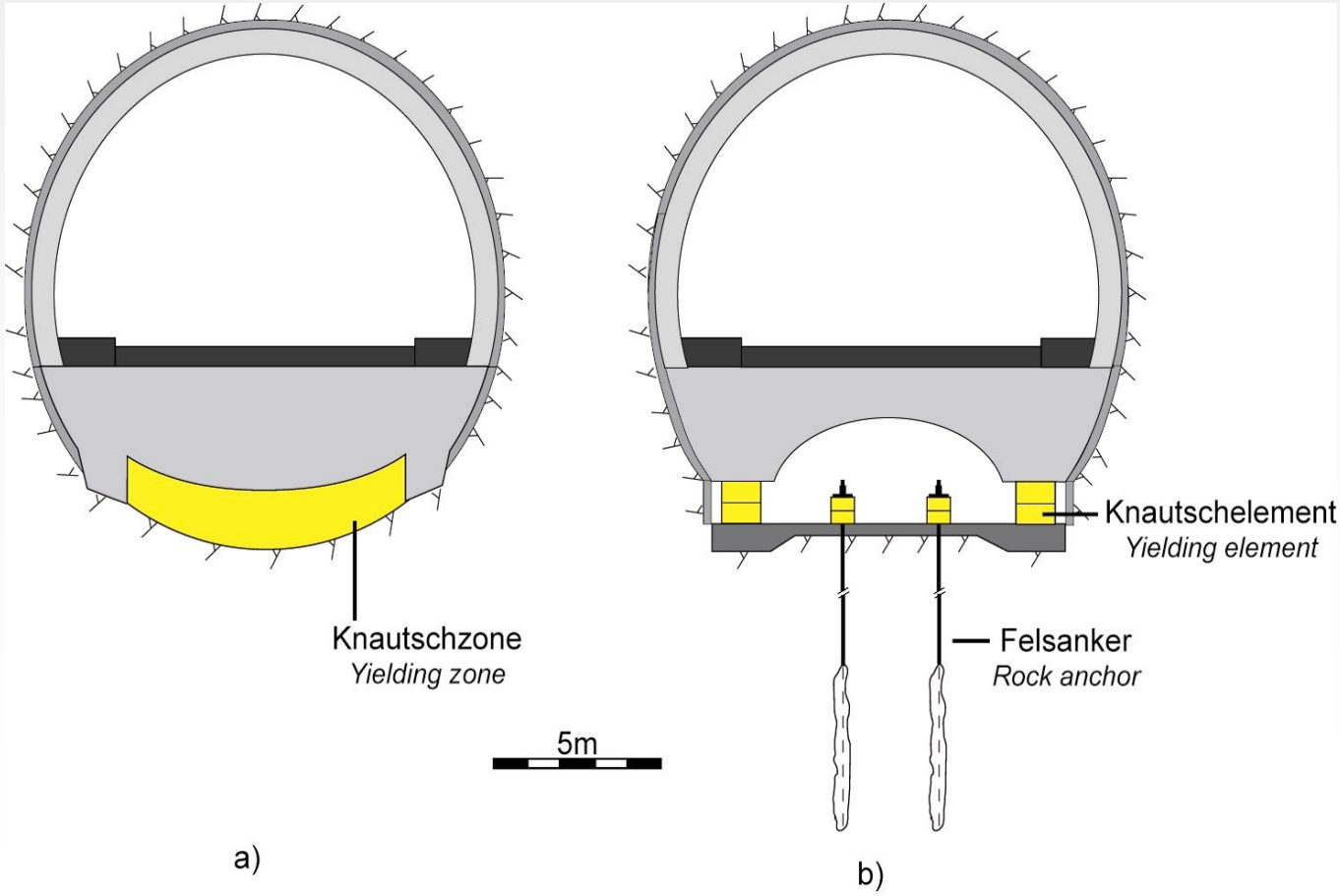
Modular Yielding Support

Heave zone 1



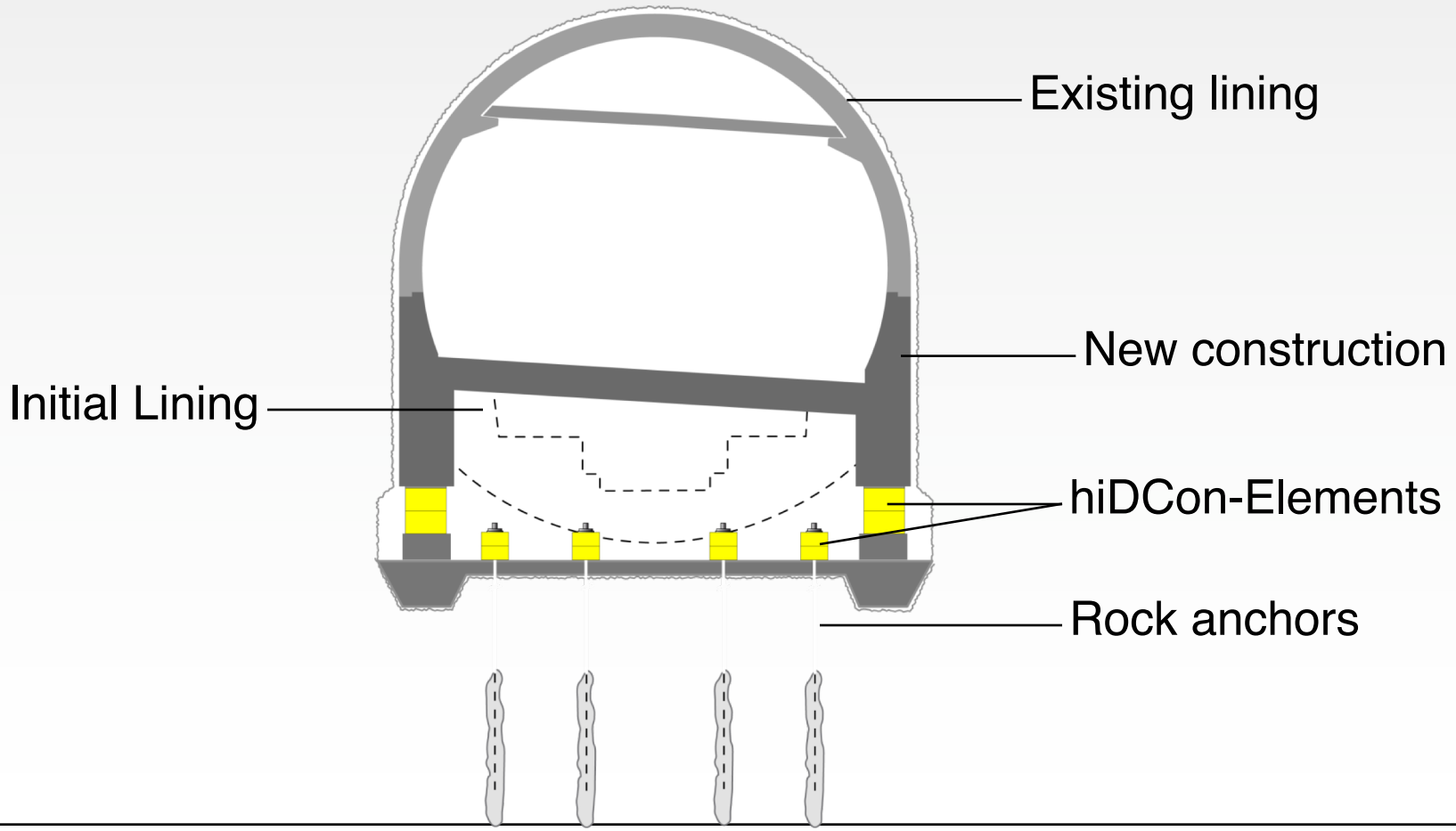
Modular Yielding Support

Alternatives



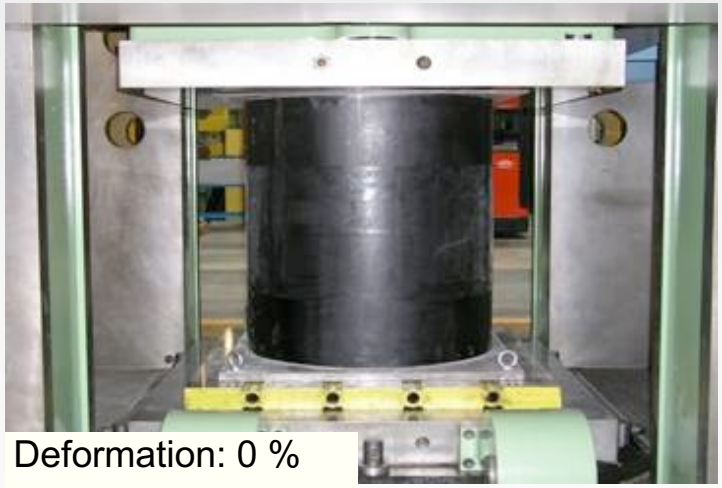
Modular Yielding Support

Reconstruction



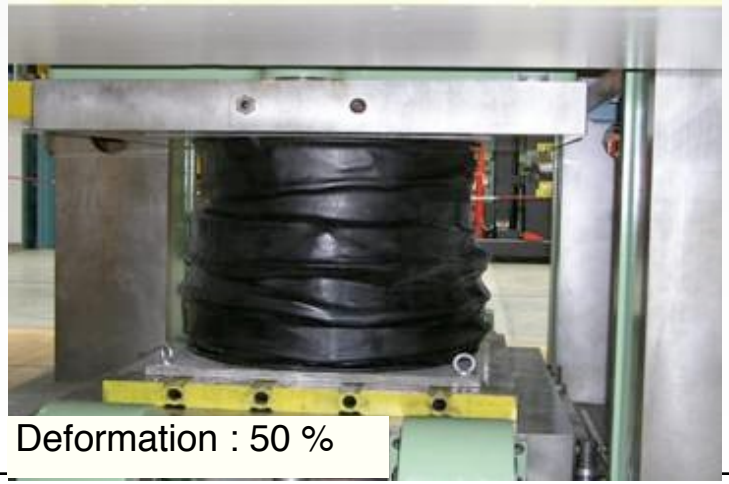
Modular Yielding Support

1:1 Pre-Tests

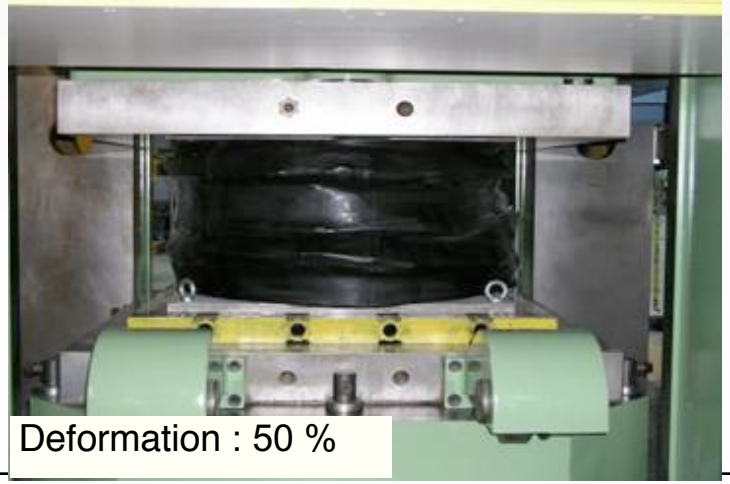


Deformation: 0 %

Deformation : 25 %



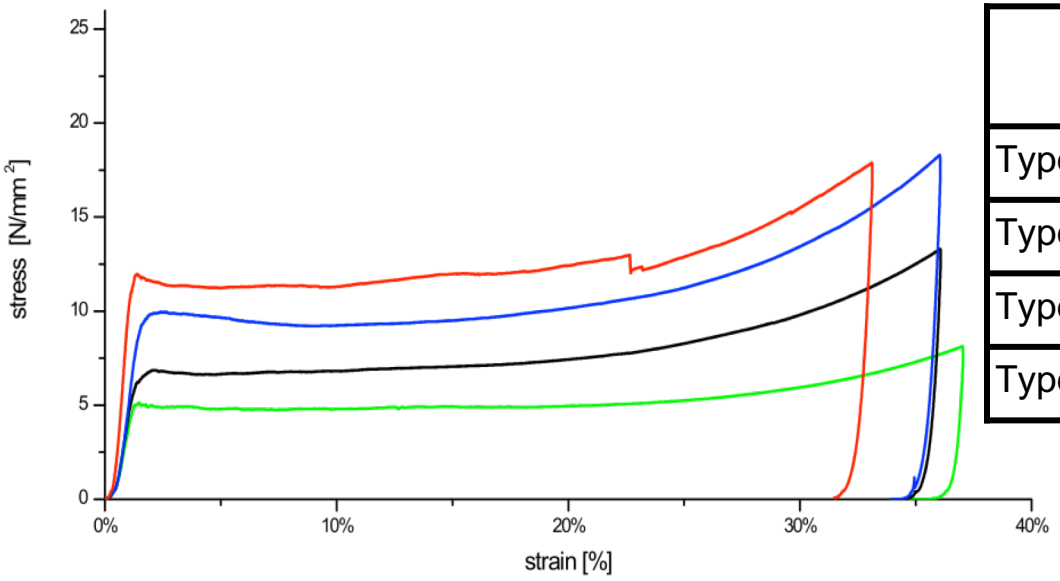
Deformation : 50 %



Deformation : 50 %

Modular Yielding Support

Foundation element



	Yield stress σ^* [N/mm²]	Yield stress σ_{max} [N/mm²]
Type D	11.8	16.5
Type C	9.4	14.2
Type B	7.1	11.8
Type A	4.9	10.2

Modular Yielding Support

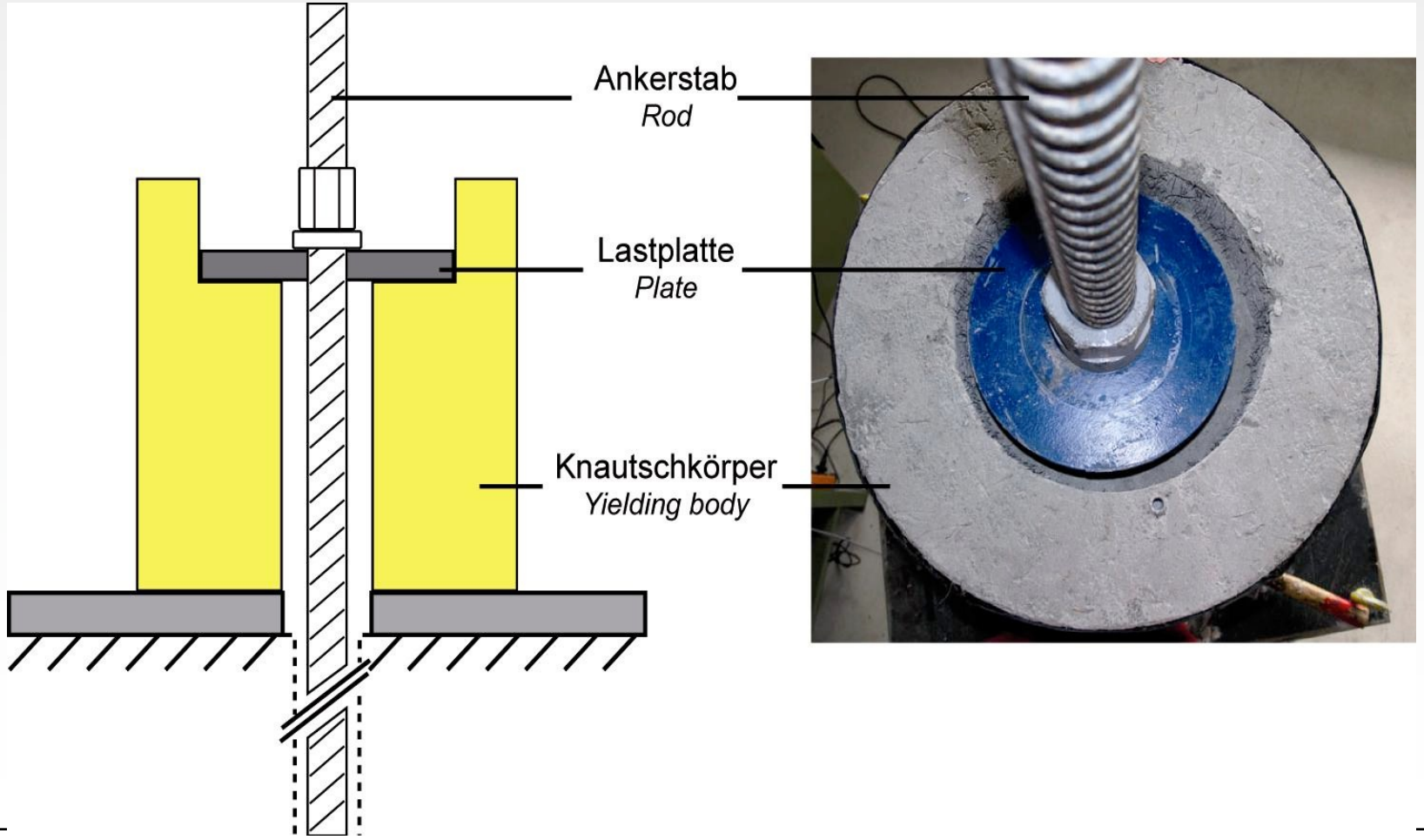
Anchor element

Modular Yielding Support

Anchor elements

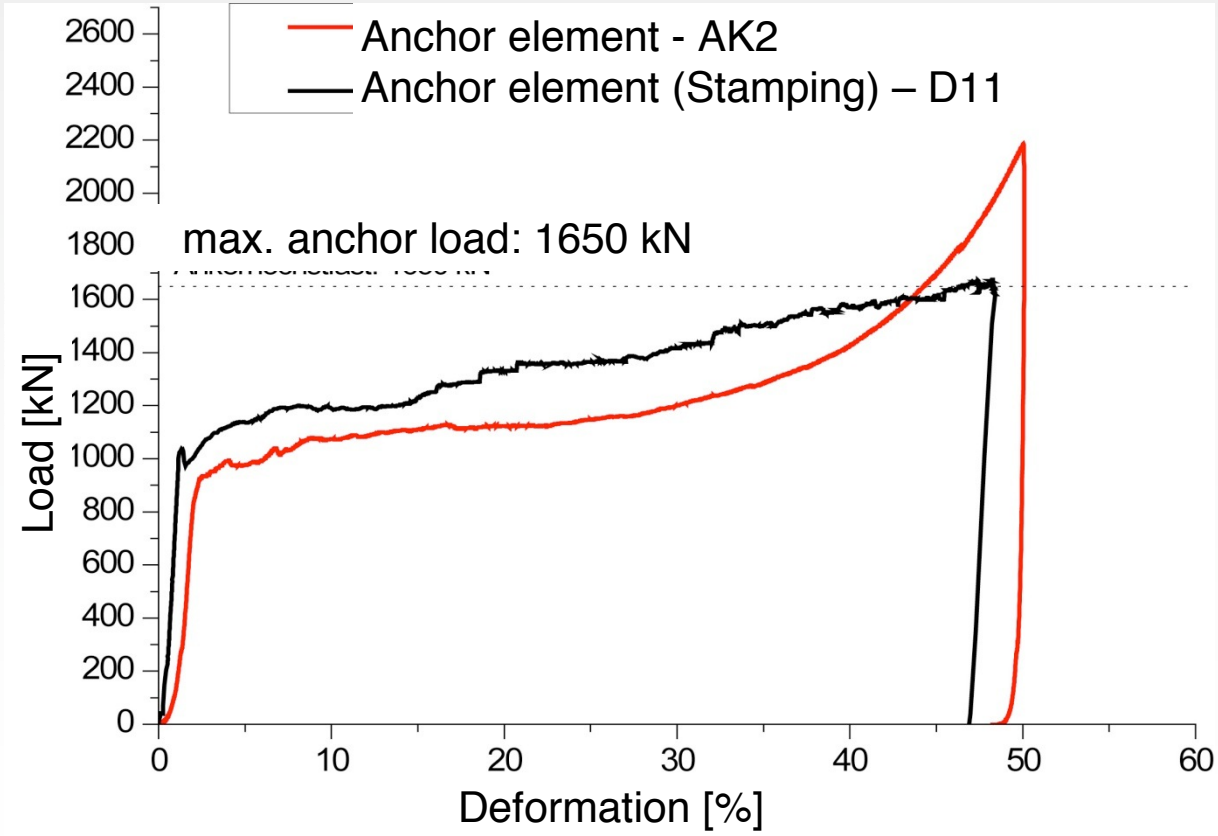
Modular Yielding Support

Anchor element (stamping principle)



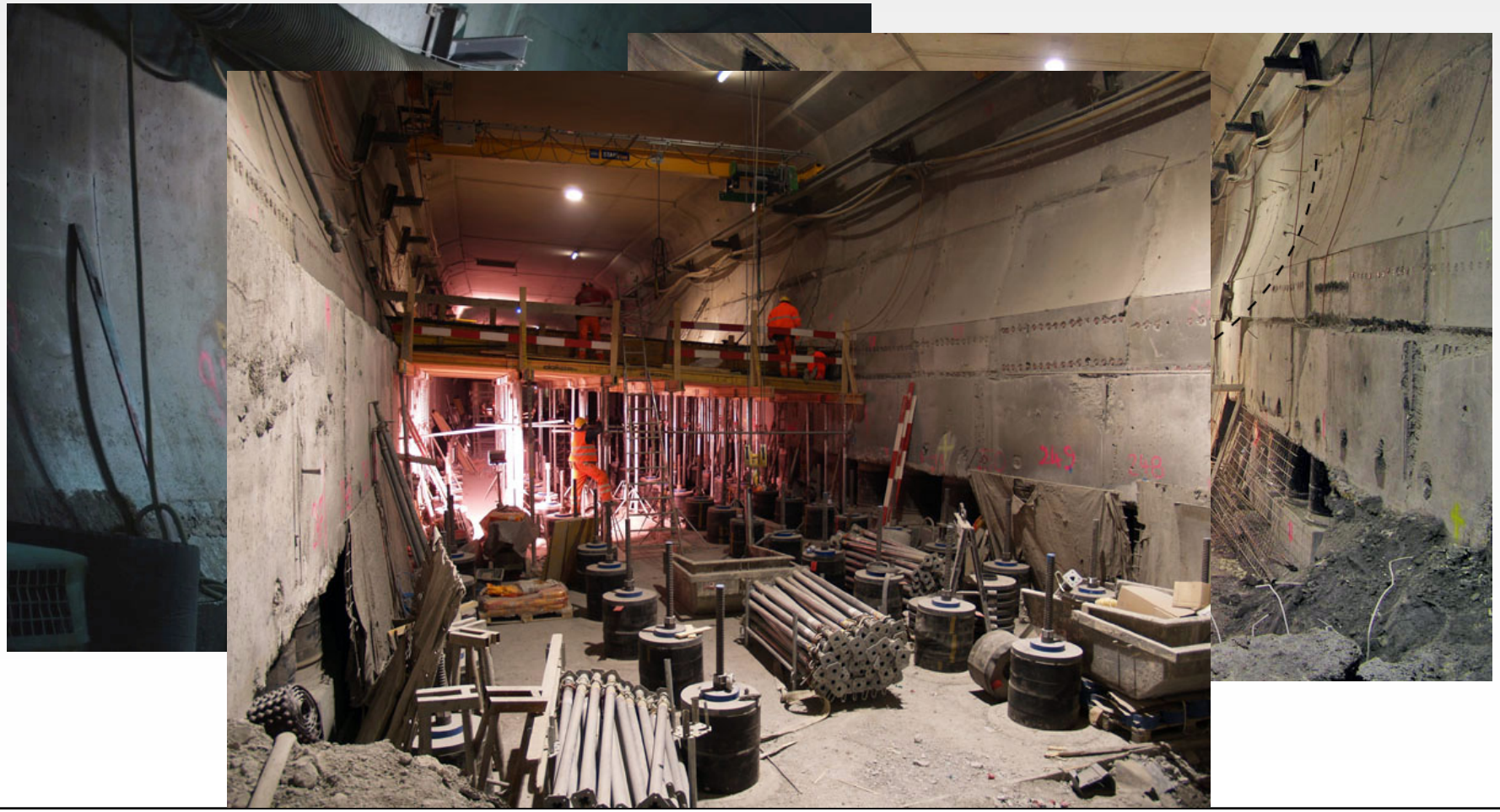
Modular Yielding Support

Anchor element (stamping principle)



Modular Yielding Support

Reconstruction

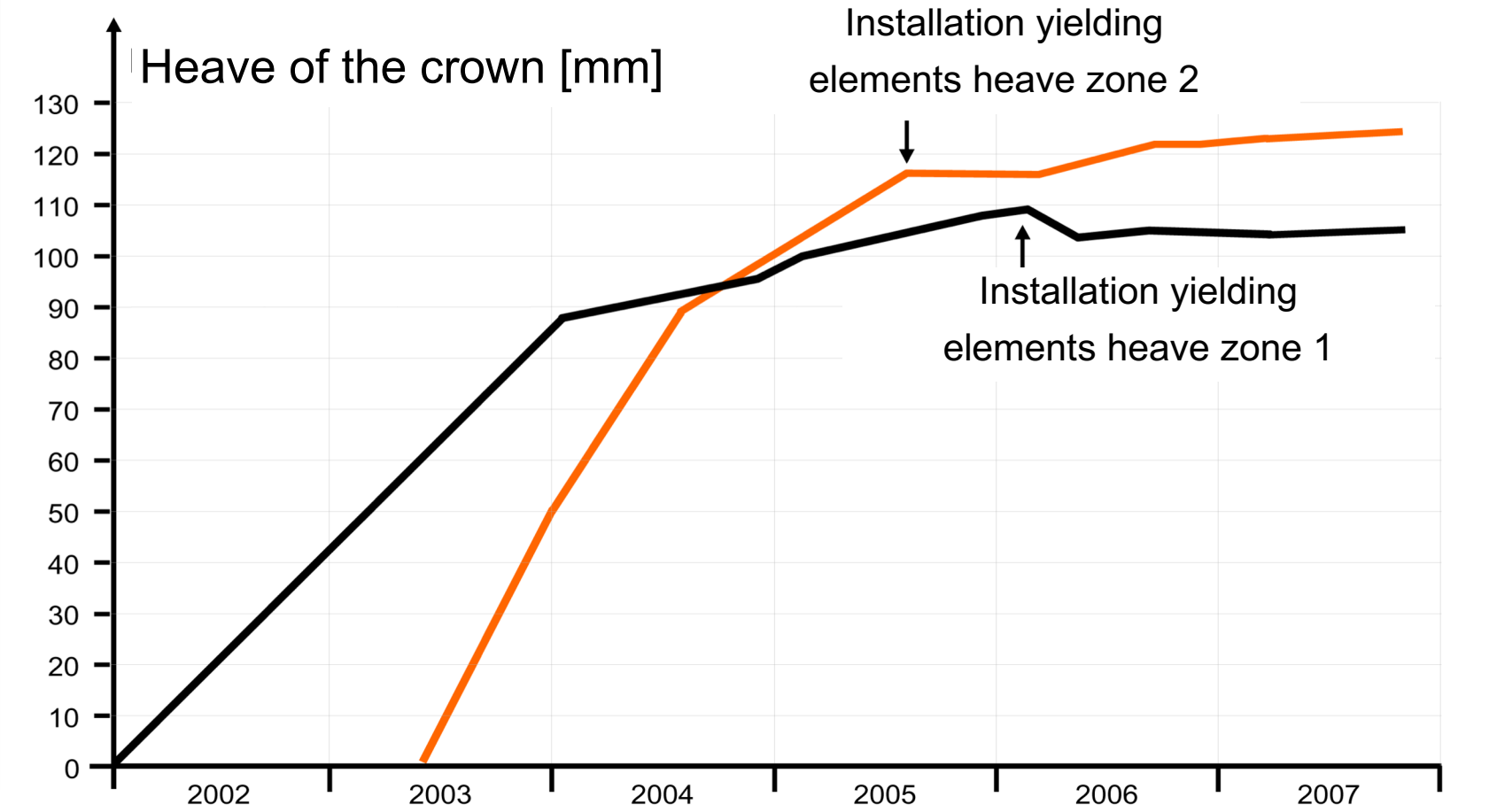


Modular Yielding Support

Reconstruction

Modular Yielding Support

Heave measurements



► Compressible Intermediate Layer

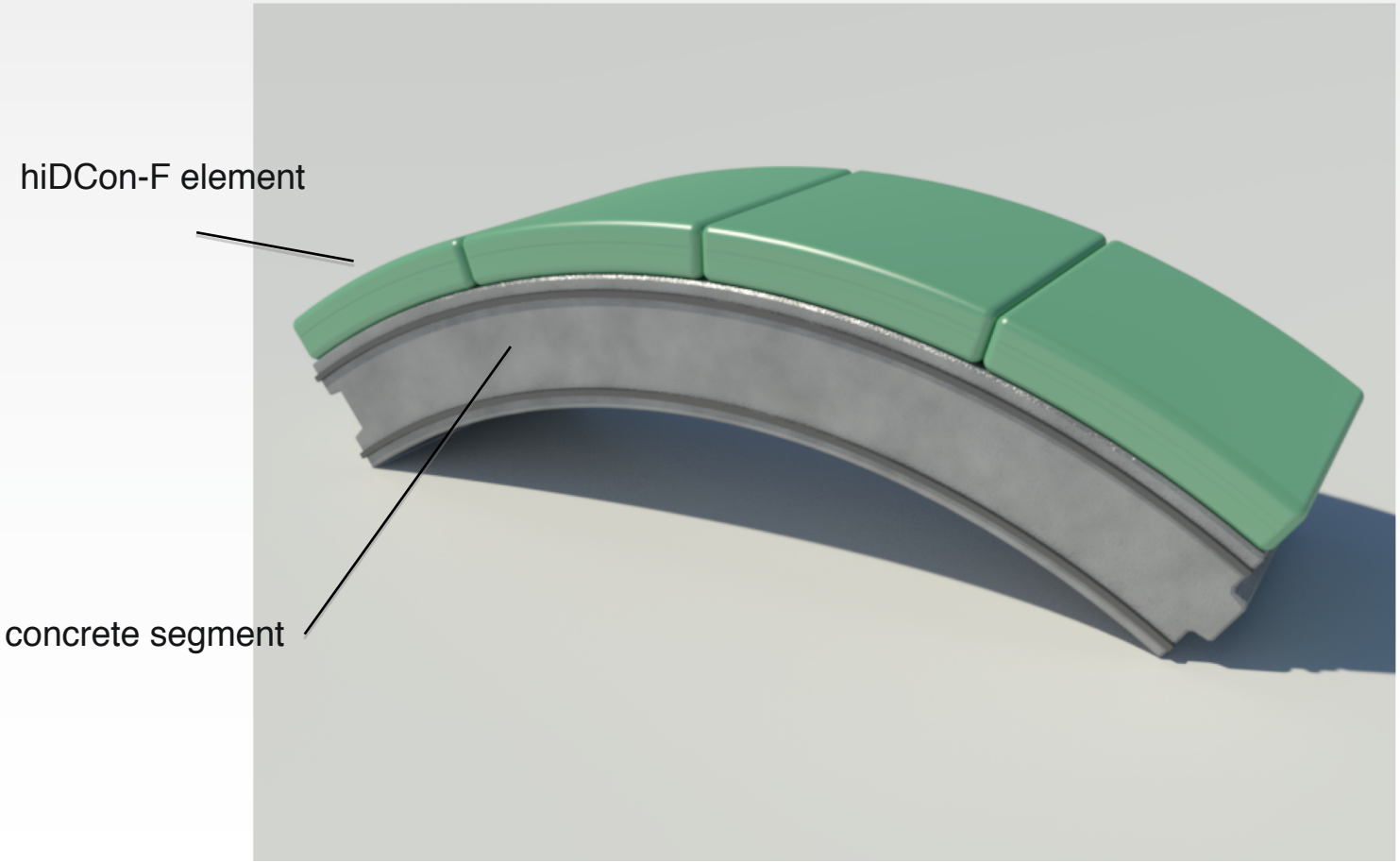
The development of Compressible Intermediate Layers for TBM:

Requirements:

- Enabling TBM applications in tunnels and shafts with high ground pressure development on the lining
- Compatibility with handling and erection of commonly used prefabricated concrete segments
- Integration of the compressive intermediate layer into the concrete segments
- Cost saving in squeezing ground

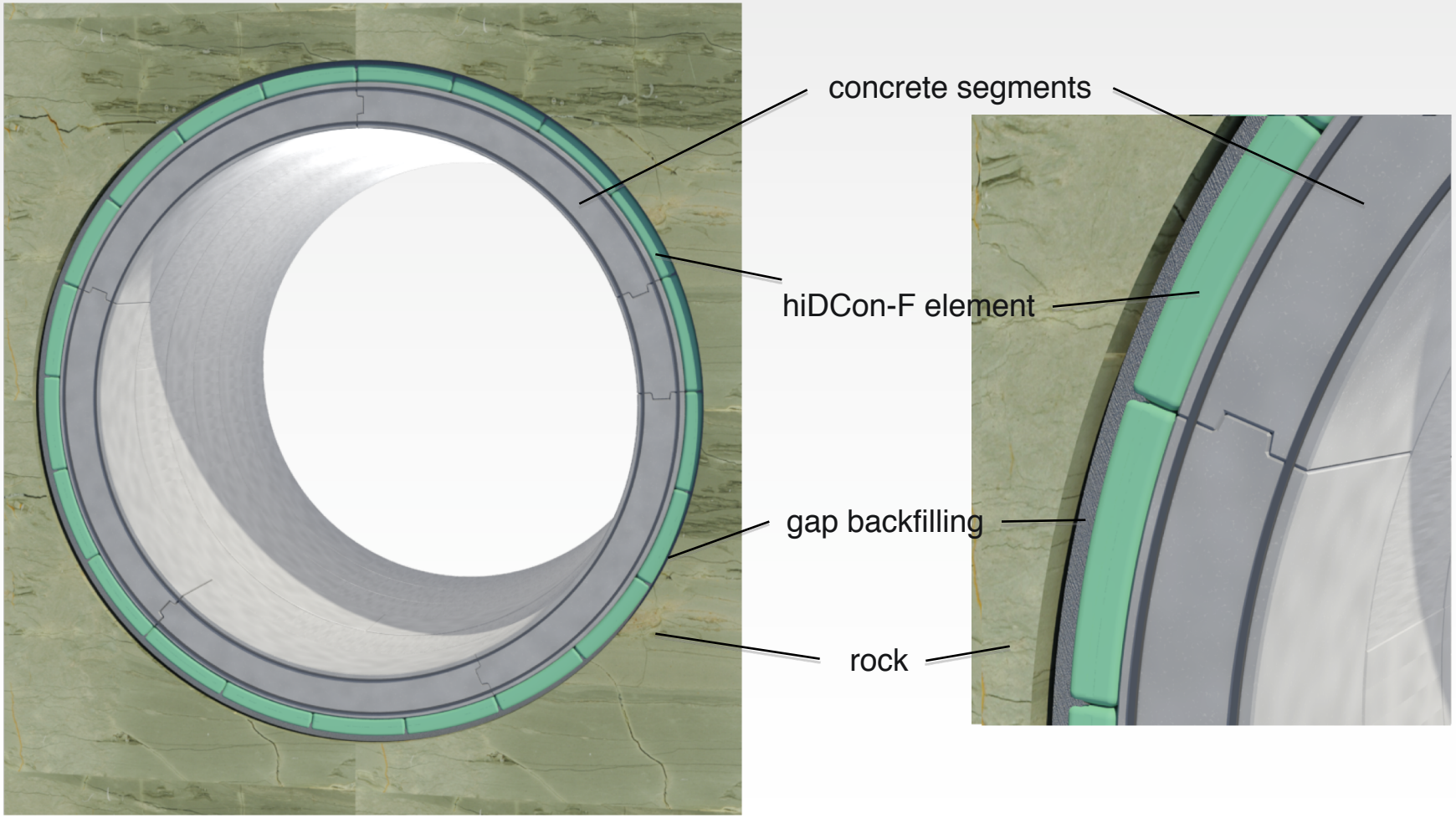
► Compressible Intermediate Layer

TBM application in squeezing and swelling rock



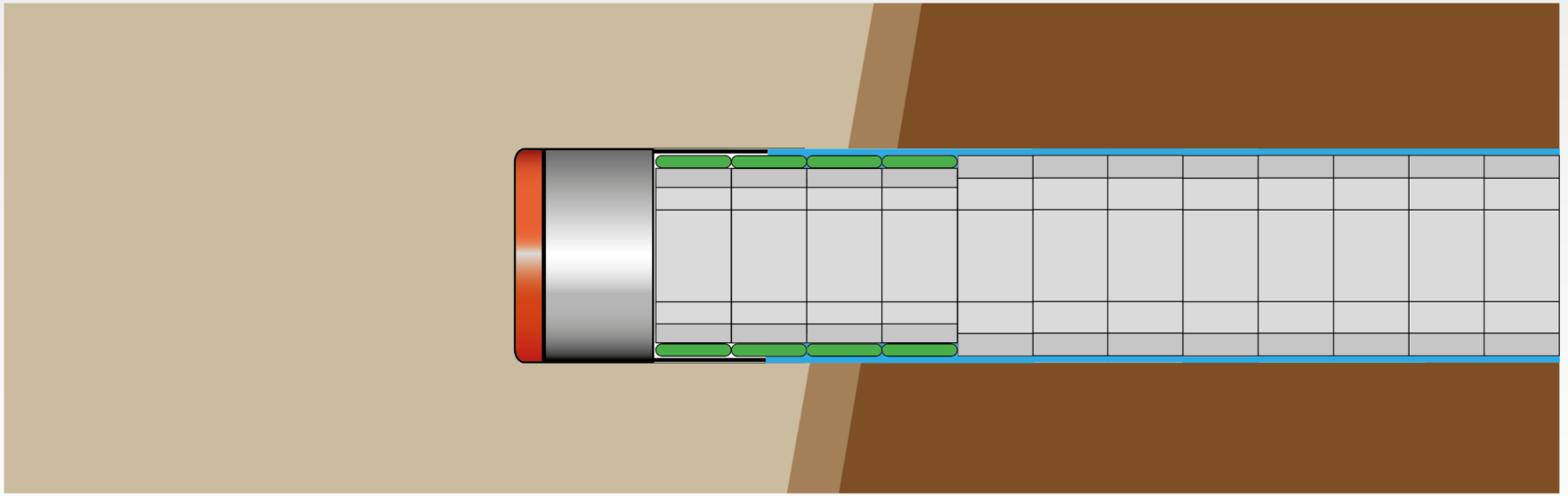
► Compressible Intermediate Layer

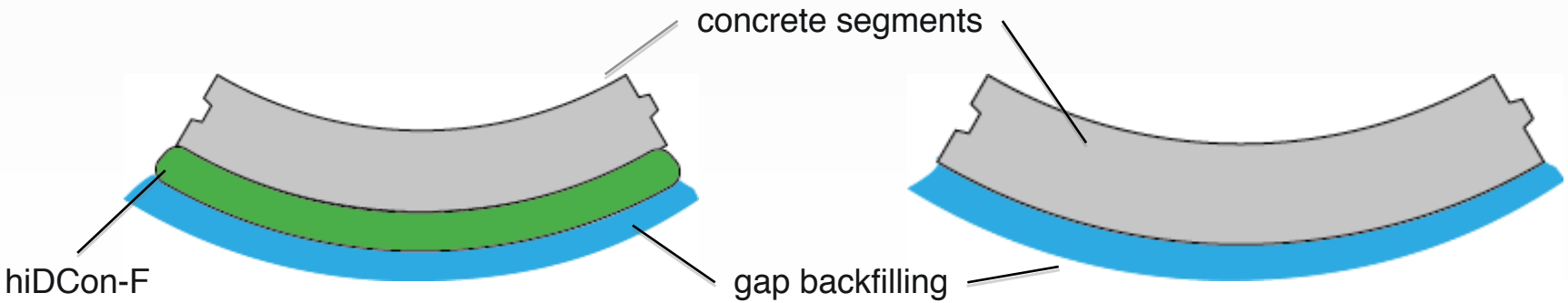
TBM application in squeezing and swelling rock



► Compressible Intermediate Layer

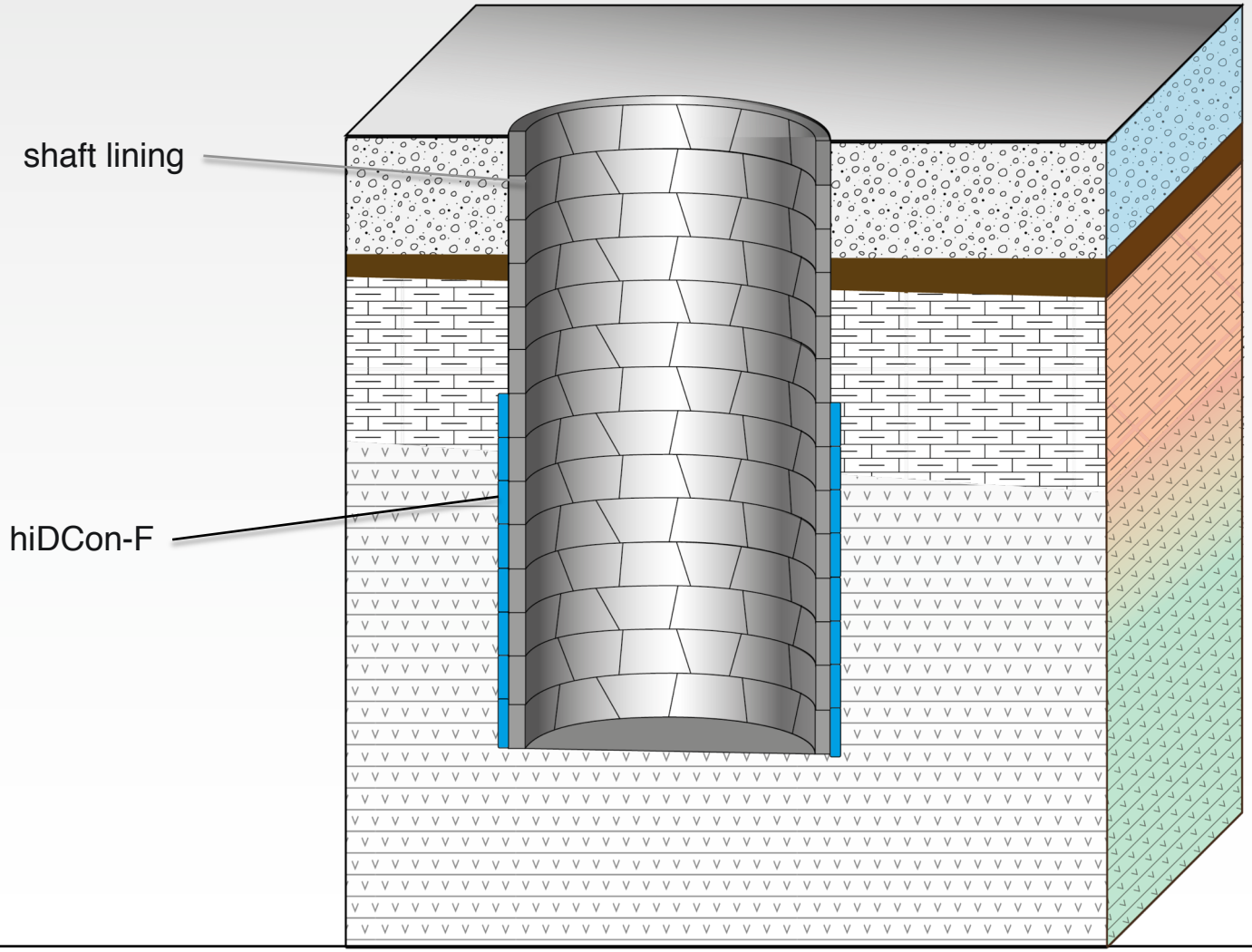
TBM application in squeezing and swelling rock





Compressible Intermediate Layer

Application for shaft sinking



► hiDCon-F

Development of hiDCon-F

hiDCon-F is an advancement of the proven cement based hiDCon mixture.

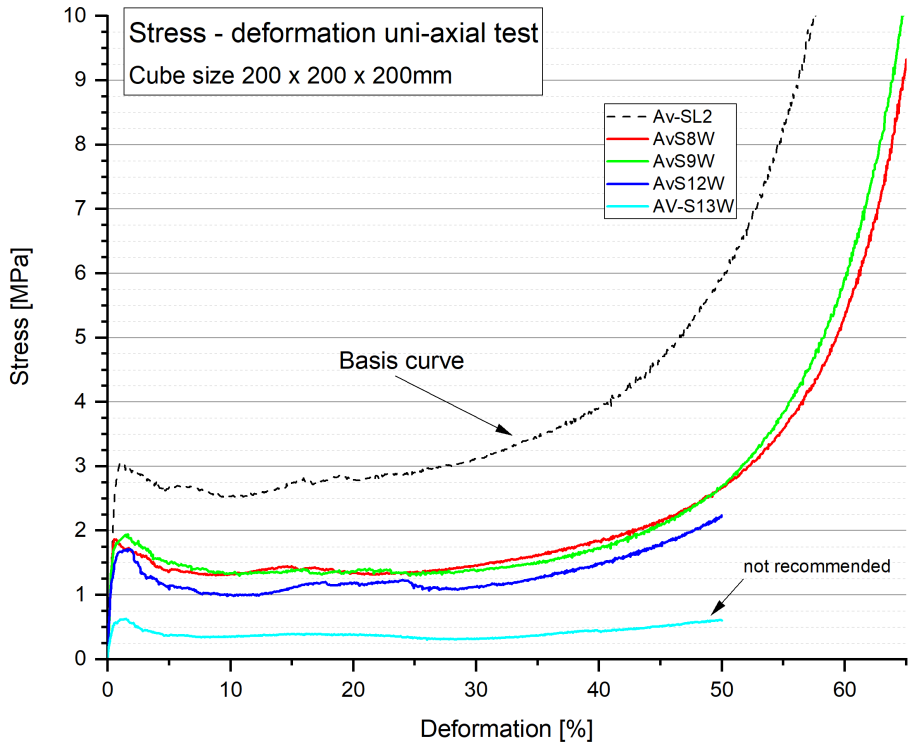
Due to an innovative combination of new additives and novel reinforcement components the typical, plateau style stress-deformation behaviour of the hiDCon element was achieved on considerable lower yield stress levels.

Fully constrained lateral strain load tests of hiDCon-F elements reveal stress – deformation curves which are most favourable for area – measured applications.

► hiDCon-F

stress – deformation behavior

Typical hiDCon-F stress – deformation curves



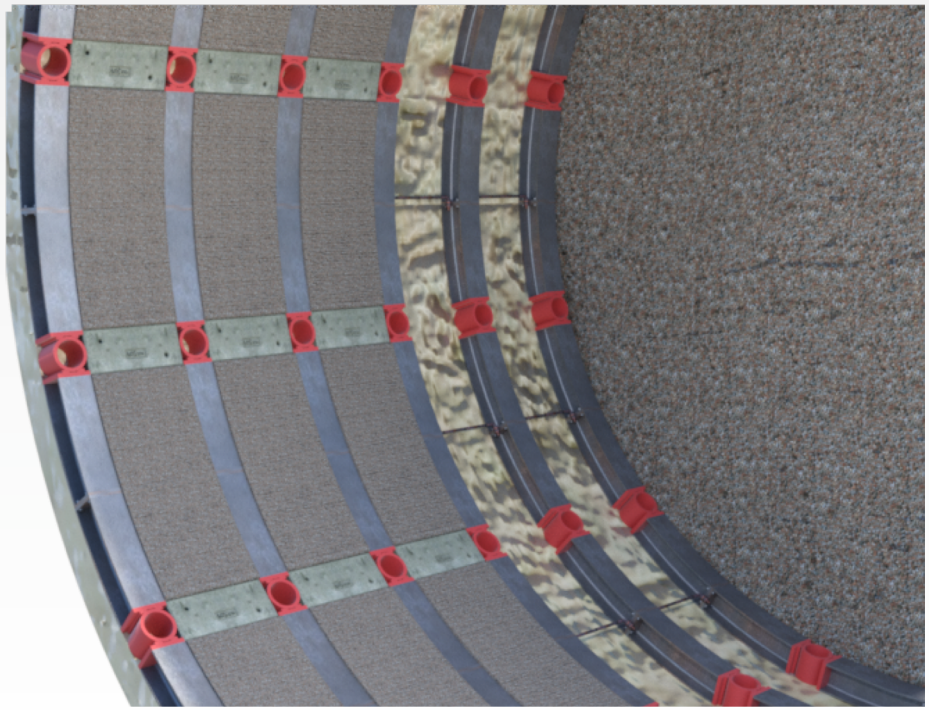
► NEW‘s

Development of hiDSte
high Deformable Steel element

Potential solution to cross heavily squeezing rock zones (example: TELT, charbon houillère)

► hiDSte

Development of hiDSte

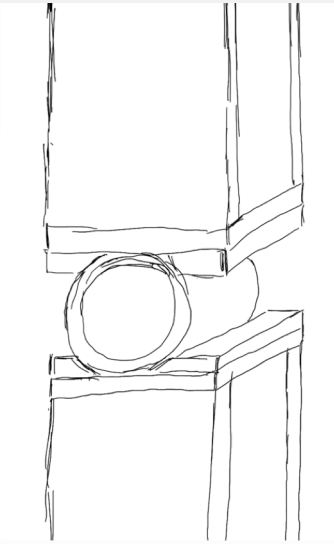


Target of development:

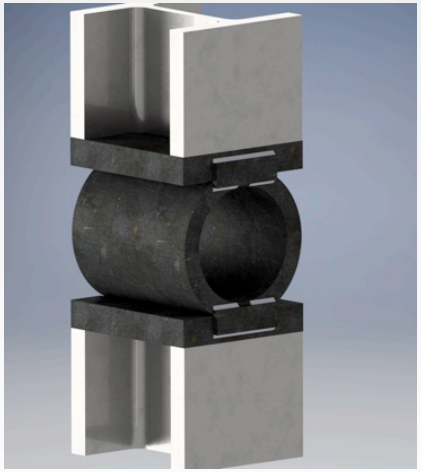
- An element to enable deformation for sections with a higher load capacity as TH- sections or lattice girders.
- Element with moment bearing and shear force capacity.

► hiDSte

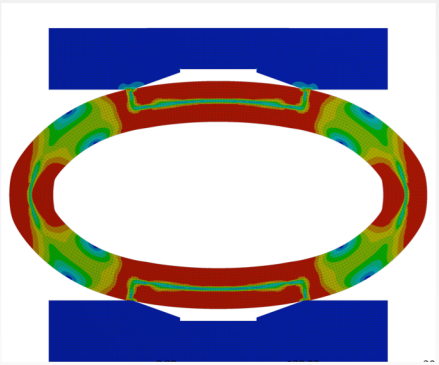
Development of hiDSte



Idea

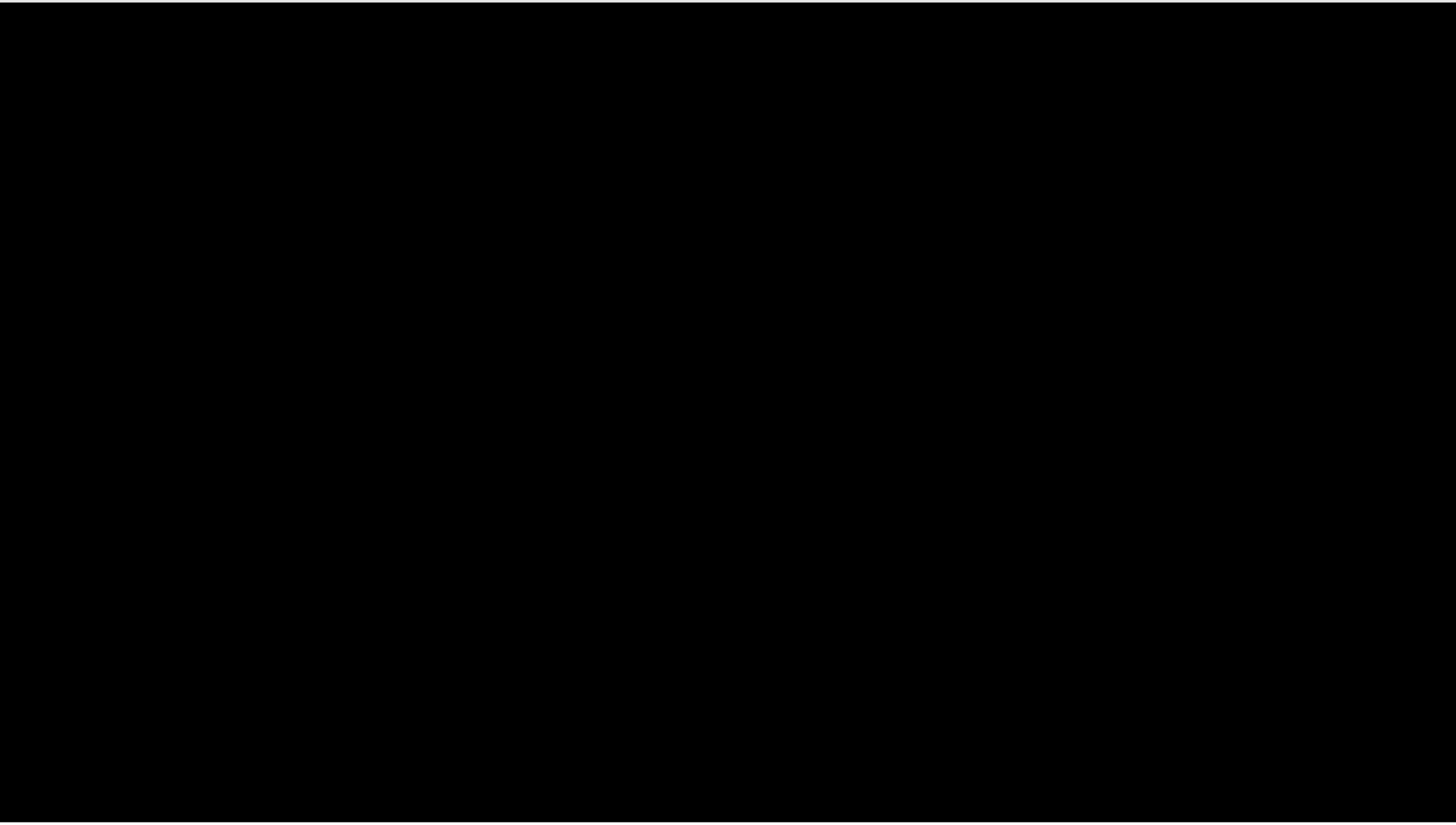


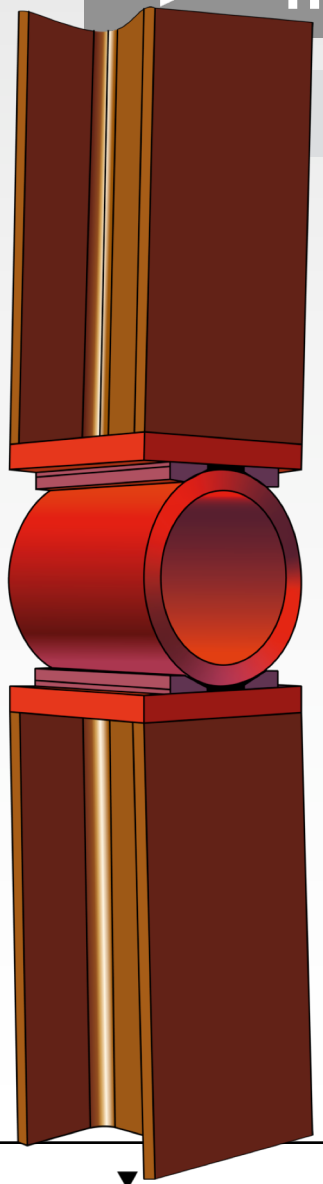
Technical drawing



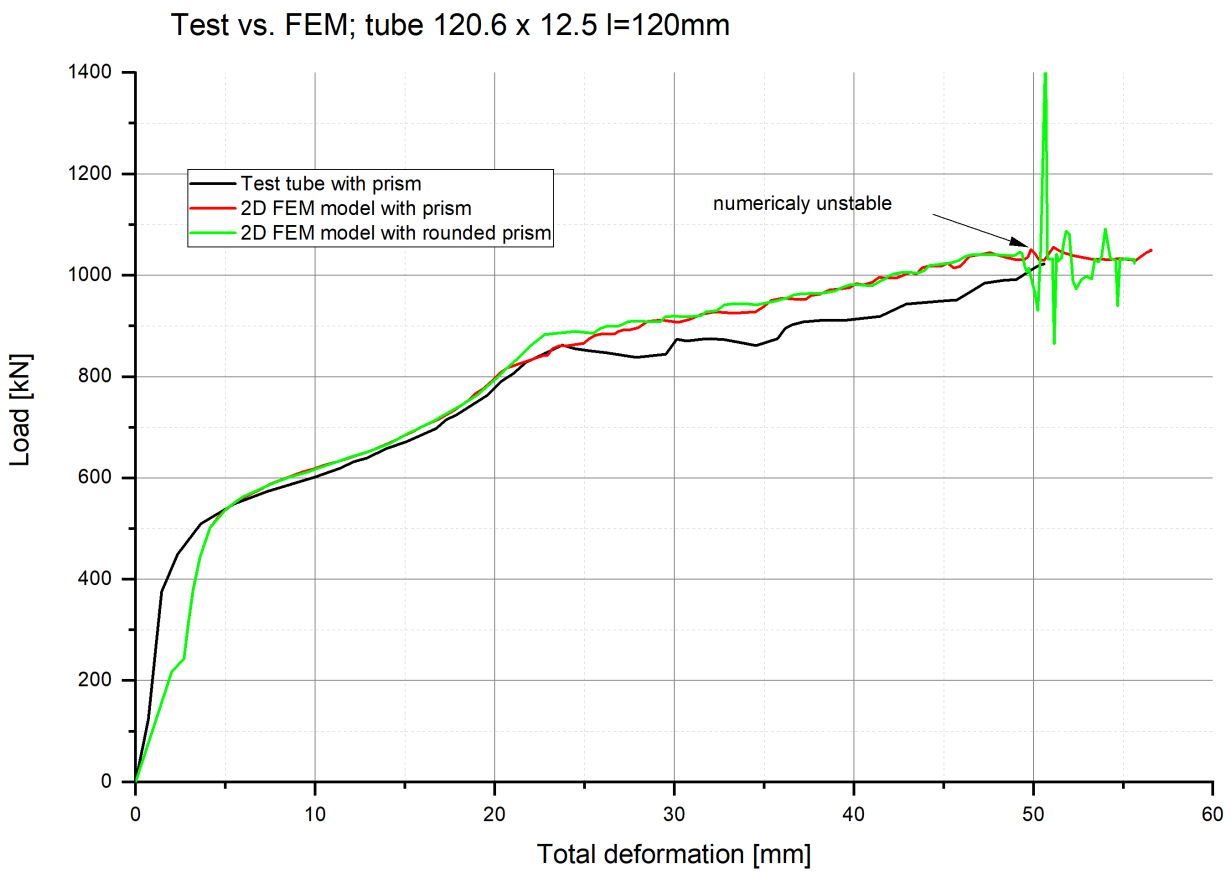
Numerical calculation

Validation of numerical calculation





Development of hiDSte



Source: Paper FGU'07

Thank you for your attention